The AMSAT Journal

Incorporating the AMSAT Newsletter
Volume 14 No. 3 May 1991

Editor: ***Drew Deskur, KA1M***
Managing Editor: ***Robert M. Myers, W1XT***

Microsat Packet Gateway Operations

AKNET is a network of seven AA4RE and WØRLI packet BBS stations in Anchorage, Fairbanks, Juneau, Ketchikan, and Homer, Alaska. The network serves approximately 300 packet users in the State, which has a population of 550,000, over half of which is located in Anchorage.

By John Lawson, NL7NC
3731 Steller Drive
Anchorage, Alaska, 99504

Packet radio operation in Alaska has in the past suffered from extremely long distances between stations (800 miles from Anchorage to Juneau), a lack of redundancy in network links, and very poor high-latitude HF propagation conditions during winter months. Installation of VHF repeaters is difficult or impossible due to site conditions and lack of line power for operation at the high VHF power levels required. Intrastate traffic forwarding was vastly improved in 1989 with implementation of the ICEWORM Packet Radio Network. ICEWORM is a joint effort of Amateur packet operators and the State of Alaska Division of Emergency Services, and consists of NET/ROM nodes and VHF repeaters in Anchorage, Fairbanks, and Juneau that are linked via existing DES microwave and satellite emergency communications links. The ICEWORM network provides 100% reliable traffic forwarding between Alaska's three largest cities.

The same difficulties involving intrastate packet traffic forwarding also exist for interstate traffic forwarding between the "Lower 48" and Alaska. It is 1,450 air miles from Anchorage to Seattle, Washington, which is the closest contiguous U.S. city to Alaska. All packet traffic going to/from Alaska is currently forwarded using 300 baud HF on 40 Meters through a network of U.S. and Canadian packet BBS stations stretching from Juneau south through Ketchikan and British Columbia to Seattle. Although very reliable during periods of good HF propagation, the network suffers during periods of poor propagation, resulting in "blackout" periods of little or no outside traffic lasting several weeks at a time during winter months. Attempts have also been made to provide connections with 20M packet traffic nets in the U.S. from Alaska, but once again, poor propagation and long distances limits the effectiveness of this method. Efforts are ongoing to improve HF capability using APLINK and AMTOR protocols.

Microsats !

Research at the NL7NC BBS into the possibility of using the Microsats for packet traffic forwarding to/from Alaska began in August, 1990. With a lot of technical assistance and moral support from Mike Bennett, AL7JM, who is the AMSAT Coordinator for Alaska, I was able to purchase necessary equipment and antennas and complete installation of my Microsat station in December, 1990, just in time for the start-up of AO-16 !! The station is quite simple: a PacComm PSK-1, a Kenwood TS-140S HF trans-

(Continued on page 4)

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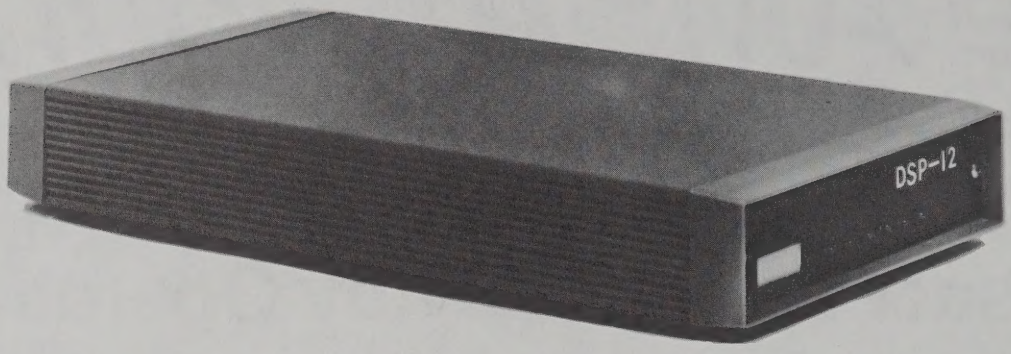

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The AMSAT Journal (ISSN: 1047-3076) is published bi-monthly (Jan., Mar., May, July, Sept., Nov.) for $15, inseparable from membership dues of $30 by AMSAT-NA, 850 Sligo Ave., Silver Spring, MD 20910, Tel. (301) 589-6062. Second Class postage paid at Silver Spring, MD and additional mailing offices. Postmaster: send address changes to *The AMSAT Journal*, 850 Sligo Ave., Silver Spring, MD 20910.

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Keeping Amateur Radio In Space

An Editorial By AMSAT President Doug Loughmiller, KO5I

AMSAT's motto for 1991 is "Keeping Amateur Radio in Space". The month of June brings a unique chance for each AMSAT member to make a substantial contribution to AMSAT's efforts to keep our hobby in space. No I don't mean a fund raising drive and I am not talking about a new unscheduled satellite launch opportunity. I am talking about using space in support of public service.

At the very core of Amateur Radio is the performance of public service. As each year passes the Amateur community faces more and more challenges to our rights to spectrum allocations. The continued performance by the Amateur community of public service is our main defense against the take over of our spectrum by the large well funded commercial interest. No large commercial interest, no matter how well funded, can perform the communication miracles that are commonplace when Amateurs respond to an emergency or natural disaster. This fact, demonstrated over and over again, is one of if not the most impor-

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Microsat Packet Gateway Operations

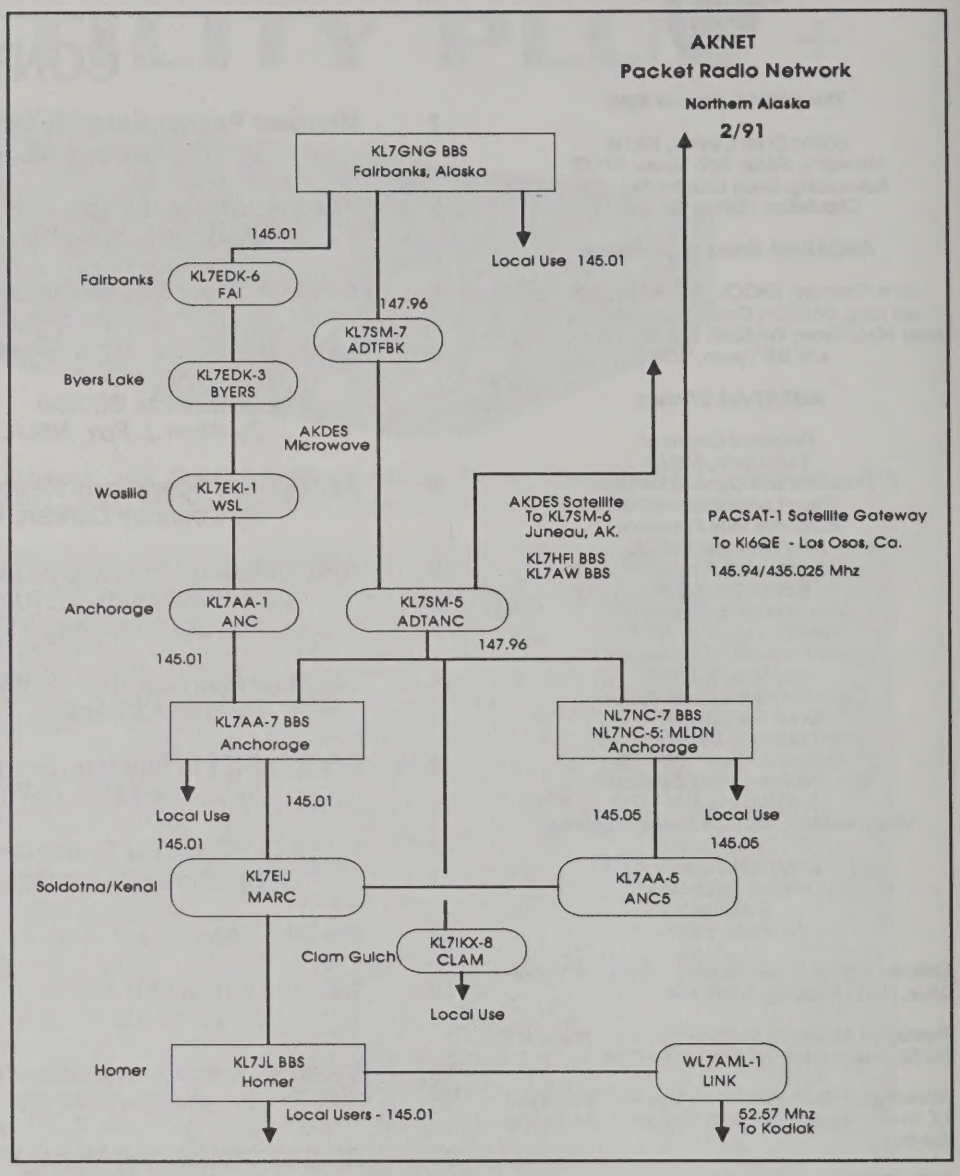
(Continued from page 1)

ceiver with Hamtronics down converter for the downlink, an ICOM IC-28A 2-Meter FM transmitter and Mirage amplifier for a 40-Watt VHF uplink, and a Cushcraft AOP-1 OSCARPACK antenna array with a Hamtronics UHF preamp and Alliance U-110 rotors. This is my first experience with satellite operation, and needless to say, there were some frustrating moments during start-up!

Anchorage is located at 61.5 N, 150W, a location that is very advantageous for working the Microsats. Because of the polar orbits of the satellites and our high-latitude location, our passes are more frequent and up to 25% longer than at lower latitude locations. The signals from the satellites seem to be totally unaffected by high-latitude geomagnetic interference. During solar storms when HF propagation is totally knocked out at high-latitudes, the Microsats come through loud and clear! In order to take advantage of the extended low-elevation passes; however, steerable array antennas are required. Initial experimentation with several types of fixed antennas yielded only limited success.

Operation of the Microsats at the NL7NC BBS has proven very quickly to be simple and reliable, even for a novice satellite user such as myself. The computer software and hardware already in place for BBS operation required no modifications whatsoever for Microsat operation. I operate the WØRLI BBS program and G8BPQ node for BBS operations on 145.05 and 147.96 MHz using a Kantronics KAM, a DRSI Type 1 Modem, and a 286 PC-Compatible with 640K RAM and a 40MB Hard Disk. A second IBM 8088 PC is used for tracking (using QUIKTRAK) and auxiliary operations.

The WØRLI BBS program lends itself very well to operation of the Microsat Ground Station software concurrently with the BBS on the same PC. The RLI program is designed to be operated in a multi-tasking environment using DESQVIEW. By running DESQVIEW in extended memory and the G8BPQ node in the background, it is possible to maintain one port for BBS operation while simultaneously operating PB or PG in another DOS window. During quiet satellite periods (or when I am at work), two RLI windows and an RLI File Server window are normally operated. As my user group is quite small, one-window RLI operation does not cause problems. With a larger user group, installation of expanded memory would allow full multi-port RLI operation to be maintained during Microsat operations. Of concern during initial operations was the affect of using two types of communications software (RLI and PB/PG) at the same time on system reliability. Results have shown no degradation whatsoever on either system with PC/TNC serial interfaces on both the G8BPQ Node and the PB/PG programs running at 2400 baud, or with PB/PG running at 9600 baud.



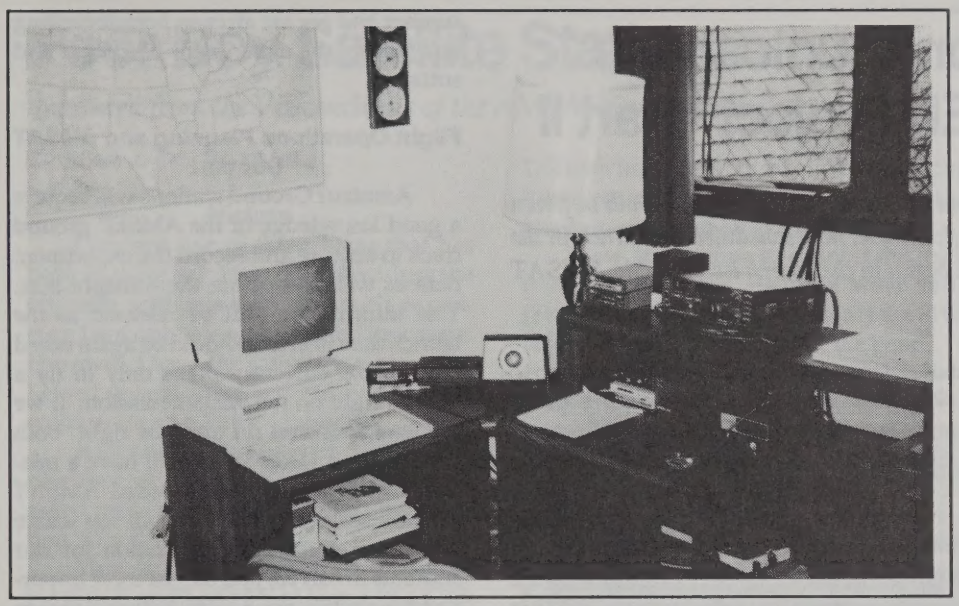
Gateway Operation

Operation of the packet gateway was initiated between NL7NC in Anchorage and David Marley, KI6QE, in Los Osos, California in early February, 1991 after successful initial experimentation between NL7NC and Courtney Duncan, N5BF.

AKNET packet traffic arriving at NL7NC is automatically transferred from the RLI MAIL.MB database to a DOS file AK.FWD in the PACSAT directory by the following commands in the RLI command file SERVER.MB:

```
O C: \PACSAT\AK.FWD OH
@C: \BBS\OUT.FWD
```

The RLI CONFIG.MB server parameter is set to cycle the server every ten minutes. By using the "OH" option in the Server command, arriving message files are exported and appended to the AK.FWD file in WA7MBL packet download format with full hierarchical addressing intact. OUT.FWD is the forwarding call file used by RLI to distinguish between intrastate and interstate traffic forwarding. Once per day (usually during the evening after I get off work), the AK.FWD file is checked for errors, proper address and content, compressed using PK.ZIP, prepared for uploading using PFHADD, and uploaded to AO-16. In PFHADD, the "BBS EXPORT" file type 2 and "ZIP" type 2 file formats are specified.



This process is repeated at KI6QE in a somewhat modified format. David does not operate a BBS at this time, but rather a TINY2 based mailbox which is regularly accessed by a large BBS in Santa Ynez, CA. This BBS has landline as well as radio access throughout the contiguous United States.

Once per day, David downloads the message files from AO-16 or LO-19, uses PHS to remove the PACSAT file headers, PKUNZIP to decompress the file and then transmits them directly to the TINY2 mailbox. AA6QD picks up and deposits mail in this mailbox regularly throughout a 24 hour period. Once again, the original hierarchical packet addressing is maintained, which is the key to successful gateway operation.

Northbound traffic repeats the proceess in reverse with some variations. There are three ways to route traffic:

1. By direct deposit in the KI6QE-1 mailbox. Operates on 145.05 MHz. Call KI6QE-1. Nearest Node SIMEON . Third party traffic accepted. No special addressing or formatting required.

2. All traffic with the hierarchical address AK.USA.NA received by AA6QD.#CENCA.CA.USA.NA is automatically routed to the KI6QE-1 mailbox. No special addressing or formatting required but the traffic must be routed via AA6QD.

3. Traffic may be routed to KI6QE @ W7AZF.#CENCA.CA.USA.NA or to KI6QE @ AA6QD.#CENCA.CA.USA.NA but in this case the hierarchical address line must be the first line of the text. The subject of the message should be AK Gateway.

All traffic not following one of the above will go by presently operating HF gateways. In the event satellite facilities are not available AA6QD will automatically route traffic through HF gateways so no special action is required by originators or SYSOPS.

David then sends all traffic received by any of these routes to NL7NC via AO-16 or LU-19 and the traffic is downloaded at NL7NC, run through PHS, decompressed and placed on AKNET. Once again, the RLI File Server is used to take the decompressed files and import it to the RLI MAIL.MB database using the following command:

```
|C:\PACSAT\*.IN OH
```

Bulletins

I have been copying AMSAT bulletins from AO-16 and UO-14 for some time now. David is also initiating forwarding of general-interest bulletins to Alaska, such as the *ARRL Reports*, *W5YI Reports*, and RTTY and DX bulletins for download and distribution on AKNET. By maintaining full hierarchical packet addressing, any of these bulletins that are also received via the existing HF net will not be duplicated, thus providing more opportunity for other types of bulletins to be sent through the HF net and providing more timely bulletin traffic for Alaskan users.

Emergency Communications

Use of the Microsats for long-distance emergency communications has literally endless possibilities. South-Central Alaska is located on a very active portion of the Pacific "Ring of Fire". The most powerful earthquake in modern history devastated Anchorage and the Alaskan Gulf Coast on Good Friday, 1964 with a magnitude of 8.6 on the Richter Scale. During and after the quake, which caused portions of the Cook Inlet area to rise and fall in excess of 30 feet, Amateur Radio operators for many days provided the only means of communication between Alaska and the outside world.

It has long been known that our existing HF packet link to the U.S. could not support the large volume of H&W traffic that would be generated during an emergency or natural disaster. Use of the Microsats will provide us with a very reliable means of handling emergency packet traffic. The NL7NC BBS is equipped with full UPS and emergency generation capability, and portable PACSAT operation has successfully been demonstrated.

The Future

As the PACSAT Broadcast Protocol software becomes more fully automated, gateway operation will become even easier than it is today. Even now, use of the gateway is no more difficult than HF forwarding, which can be considered to be "semi-automatic" at best. Also, as more and more BBS SYSOPS become aware of the capabilities of the Microsats and the PACSAT software, regional gateways will become operational to allow multiple point-to-point forwarding using AO-16 and/or LO-19. I am also experimenting with UO-14 at 9600 baud (boy, is it FAST !!) as the ultimate packet gateway !! Further experimentation with fixed antennas capable of supporting extended pass operation and/or automatic tracking will also enhance operation, eventually leading to a completely automatic forwarding system for U.S. and World-Wide traffic forwarding.

I would like to take this opportunity to thank AMSAT and the entire AMSAT Command Team for the wonderful opportunity that they have provided us. Rest assured, the folks at AKNET will put the Microsats to good use !! ■

Amateur Satellite Communications and the SEDS AMSEP Project - Part II

The second flight of the Small Expendable-Tether Deployer System, (SEDS) will be flown as a secondary payload on a Delta II 7925 launch vehicle, now scheduled for launch in the middle of 1993. Part II finishes the story which began in the March issue of The AMSAT Journal, *page 26.*

By Dennis Wingo
The University of Alabama in Huntsville SEDS

Ed Stluka, W4QAU
Marshal Amateur Radio Club MARC

Chris Rupp, W4HIY
Marshall Amateur Radio Club MARC

The power required for this experiment is about five Watts, including power for the compression engine and camera system. The weight is about seven pounds, most of which is shielding for the processor and the weight of the PAL lens. It is desired that after the LDTDE mission ends that SEASIS will continue to be used to provide a unique source of wide field imagery not available from any other system.

Free Electron Wiggler LASER

This experiment is provided by the Milwaukee School of Engineering. Its purpose is to determine if the free plasma of the E and F layers of the Ionosphere is sufficient to power a LASER of this type. This experiment is not mounted on the satellite, rather it will be mounted on the second stage and its telemetry will be captured by the deployer's data system.

AMSAT Mode A/J Transponder

The transponder pair proposed for the AMSEP is a combination Mode A/J transponder similar in frequency operation to the one flown on OSCAR 8. The proposed Mode A uplink frequency is 145.820 to 145.880 MHz. The downlink frequency will be 29.300 to 29.360 MHz.

The proposed Mode J uplink frequency is 145.820 to 145.880 MHz. The downlink frequency will be 430.930 to 430.990 MHz.

It is further proposed that the design and construction of the AMSAT transponder pair will be the responsibility of the DOUG, which will operate a proposed AMSAT/NA spacecraft lab in the Detroit area. The design will use advances in technology to enable the transmitters to be up to 80% efficient. Design features incorporated into the Microsats such as variable transmitter power will also be used to allow the maximum rf output from the available power of the satellite. The preliminary baseline of maximum rf power output from each transponder is four Watts. Due to the electrical power limitations of the satellite only one transponder at a time will be commanded on. This will be alleviated when the LDTDE mission is over and the accelerometer is commanded off. After that time both transponders will be capable of simultaneous operation.

Two 9600 bps telemetry channels will be provided for the SEP experiments. These will be located at the bottom of the frequency allocation of the Mode J transponder. It is desired that a slower bit rate telemetry channel be made available on the Mode A downlink side to enable image and accelerometer data capture by Mode A users during the post deployment phase of the experiments operation.

Satellite Operational Systems

The AMSEP systems necessary to complete the satellite are the Electrical Power System (EPS), Command Data System (CDS), Mechanical Support Structure (MSS), and Thermal Management System (TMS). With the exception of the EPS these systems are in the preliminary design phase. Since this will become an OSCAR at the end of the LDTDE mission we are undertaking discussions on incorporating the AMSAT Microsat technology as integral to the design of the other systems. It is in each groups best interest to retain as much as possible hardware and software compatibility with the Microsats. Personnel attached to this project already have extensive experience with the 80186 compatible processor used on the Microsats. We feel that this processor is a good choice for our CDS system for the same development cost issues addressed by Jan King in his paper on the Microsats.[8] Also with our relatively short time span until launch we feel that any shortening of the development process is well met. Our designs for the systems mentioned above will be finalized by December and we are already breadboarding and testing the experiment hardware and software.

Flight Operations Planning and AMSAT Support

Amateur Ground stations will require a good knowledge of the AMSEP ground track to acquire and record the experiment data as well as operate the transponders. This information will be released as the launch date nears. It should be again noted that NASA currently plans only to fly a dead weight on the SEDS 2 mission. If we are tenacious and do our jobs right both AMSAT and UAH SEDS will have a mission that will provide a needed AMSAT satellite service to its users, all too scarce hands on engineering education for our students involved, and maybe most important develop working relationships between those interested in furthering both education and Amateur Radio technology. Isn't that what Hiram Percy Maxim envisioned for the Amateur Radio art? AMSAT support is crucial to the success of this venture. Our student organization consists of volunteers as much as AMSAT does. We as students have the same time pressures as AMSAT members do (in most cases with no job to support us!). We have the enthusiasm, dedication and drive necessary to complete this job. All we ask is advice and guidance. That is an Elmer's role. Amateur Radio for 90 years has prospered because of the Elmer spirit. Together we will succeed.

I would like to express my thanks to John Champa, K8OCL, for being a receptive ear and providing leadership for the transponders. I would also like to express special thanks to MARC members Chris Rupp, W4HIY, and Ed Stluka, W4QAU. They have spent much time and effort in aiding not only this but several other Amateur Radio and student space flight experiment projects. These are unsung heros for Amateur Radio and student involvement in space flight.

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Poor Boy Satellite Station

Reprinted from the Proceedings *of the AMSAT Symposium.*

By Allan J. Fox IV, N5LKJ

History

I am not one of those hams that has been chasing satellites for eons. Just the opposite, with less than one year's experience I am only a neophyte satellite chaser. However, I have the satisfaction of having helped several hams become avid satellite enthusiasts on a limited budget.

It all started about a year ago when a neighbor of mine Carl Kotila, WD5JRD, asked me to attend the Houston Com-Vention '87 with him.

That is where I met Jack Douglas, KA5DNP, and Andy MacAllister, WA5ZIB, who were giving a talk on Amateur satellites. Jack explained that the Russian satellites RS-10/11 (Radio 10/11) were in a low Earth orbit that was near circular and did not require extensive equipment or elaborate antennas to operate.

Station

My station at the time consisted of a 25 Watt two-meter all-mode transceiver. The antenna was a homebrewed ground-plane in the attic similar to one mentioned in the *ARRL Handbook.* However, my antenna was fabricated from five (5) old coat hangers and a used SO-239 chassis connector as follows.

Two-Meter Ground-Plane

First I cut the hooks off five (5) old coat hangers and straightened them out. This formed five (5) straight pieces of coated steel wire. The next procedure was to remove the paint from one end of each wire, so that a good electrical connection could be made. To accomplish this I put one end of each wire into the hot coals in our fireplace and burned the paint off.

The next step was to solder the bare end of one of these wires into the center conductor of an SO-239 chassis connector to form a vertical radiator. Now, with the aid of needle-nose pliers I bent a loop in the bare end of the other four (4) wires. This allowed me to attach them to the mounting holes in the SO-239 with four (4) #6-32 by 1/2 inch machine screws and nuts. These wires were then bent down at a 45 degree angle to serve as radials.

At this point all that remained was to cut all the wires to the proper length. With a tape, I measured each radial 20 3/16 inches and cut them. Then I measured the vertical radiator 19 5/16 inches and cut it. Since my intention was to hang this antenna in the attic it became necessary to cut an extra 1/2 inch from the vertical and install a ring lug to use as a hanger. However, you could just as easily bend an eye in it.

Now, it was time to connect the feedline and check the standing wave ratio (SWR). Without any adjustments the SWR stayed below 2:1 throughout the band.

Total cost of this antenna was less than $1.00 and about fifteen minutes construction time.

According to Jack and Andy's presentation my existing station contained half the requirements to work RS-10/11 and could serve for uplink on Mode A. Since Mode A consists of two meters upper side band or CW uplink with a ten-meter downlink the only thing needed would be a ten-meter receiver and antenna.

I bought an old SWAN 350B transceiver for $50. Now for a ten-meter antenna and my satellite station would be ready to

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go on the air. Since the SWAN was a transceiver it made sense that the antenna should be capable of not only receiving but also transmitting. Because of the simplicity and ease of construction I decided to build a dipole for my ten-meter antenna.

In searching the garage for antenna materials an old piece of 12/2 TYPE NM wire (more commonly called Romex) was located. The Romex was stripped back to bare copper and attached to short pieces of PVC pipe used as insulators. The resulting simple ten-meter dipole antenna was then stretched in the attic and connected to the SWAN. Now my POOR BOY SATELLITE STATION was almost ready to go on the air.

When, Where and How to Find The Birds

There are several ways to accomplish this. The first and easiest is to ask an avid satellite enthusiast when and where the next good orbit for your QTH will be. Another method is to use a computer with the appropriate software. We didn't have a computer in our household, but we did have a calculator. Therefore, my method was to tune in the beacon frequency and wait until it is heard. This can be tedious, but I have done it several times.

First, tune in 29.357 MHz for the RS-10 beacon and wait until you hear the beacon transmitting a series of dots and dashes. This indicates that you have now caught yourself a satellite. The next thing to do is note the time and tune through the downlink band 29.360 - 29.400 MHz while listening for a QSO in progress. This will let you know whether the satellite's orbit is tracking from north to south or south to north. Each orbit progresses 26.4 degrees west of the preceding orbit. Also each orbit takes 105 minutes. You have probably heard about Doppler shift but don't worry about it now!

Sequence of Operation

Since tracking antennas were not in my budget, here's my sequence of operation! First tune the radios to 145.870 MHz uplink and 29.380 MHz downlink and put on a headset. With satellite operation being full duplex a headset is really a good practice because feedback can be unbearable without one.

Now begin by transmitting your call sign, then send a string of dots on CW and adjust the downlink frequency for the best copy. If your dots come down in the middle of a QSO don't worry just adjust your uplink frequency up or down and repeat the above procedure. Now you are ready to call CQ and stand by for your first satellite QSO. If you want to operate phone be sure and change to the USB mode.

TABLE 1 — Frequencies of RS-10/11 Mode A.

	Satellite RS-10		Satellite RS-11	
Mode	Downlink	Uplink	Downlink	Uplink
"Beacon"	29.357		29.407	
"A"	29.360-29.400	145.860-145.900	29.410-29.450	145.910-145.950

Doppler shift noted above is minimal but noticeable on Mode A. You will hear some frequency shift of your signal and it will be necessary to compensate your downlink frequency slightly.

Summary

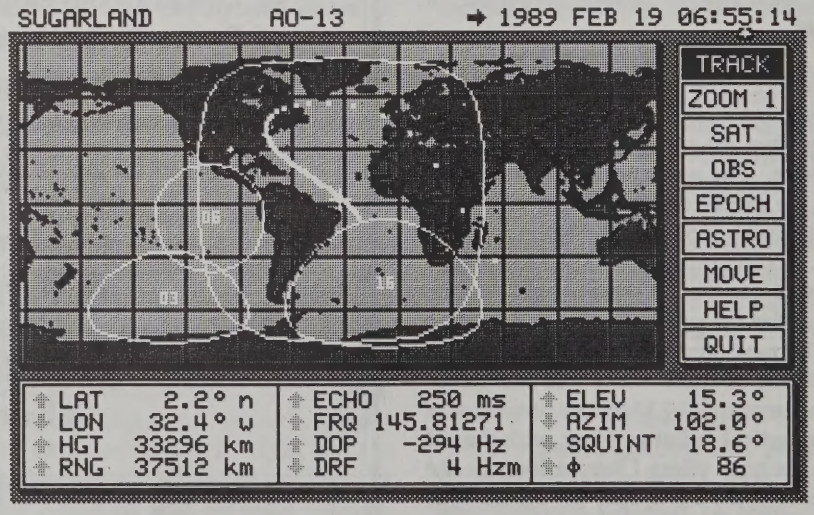
RS-10/11 are low Earth orbit satellites (only 600 miles up) and that is why they can be worked without an elaborate Earth station. On one occasion my SWAN was in for repair and while a friend was tuning it we copied a QSO on RS-11. The SWAN was only connected to a dead end piece of RG-58 coax in his attic with no antenna. Although a preamp helps for RS operation it is not necessary.

These satellites do have some drawbacks. Since they are in a low Earth orbit the average pass over any particular QTH is only about 15 to 20 minutes. Therefore, QSO's are limited, but I have made as many as four contacts on a pass. Also, their footprint only has a radius of about fifteen hundred miles. Even so, it is possible to get W.A.S. (Worked All States) via these birds for most stateside hams.

RS-10/11 have several modes of operation other than Mode A such as Mode K, Mode T, combination Modes KA and KT as well as the ROBOT (or QSO machine). However, I have no experience with them. Remember, the control on License Requirements is the uplink frequency! This makes it possible for even a Novice grade license to operate CW when RS-10 is in either Mode K or Mode T.

Good luck and don't laugh at my poor boy operation. At 1016Z on 25 November 1988 with only 25 Watts into the coat hangers I made contact and had a QSO with Musa Manarov, U2MIR, on 145.550 MHz FM direct while he was on board the Russian Space Station MIR. See you on RS! ■

GET A BIRD'S EYE VIEW
From GrafTrak II™ and your IBM® PC



GrafTrak II™ provides real-time graphic display of a flat projection map which moves under the selected satellite(sat)/Sun/Moon/star coverage circle and updates once per second. Features include spherical projection views, graphic screen dumps to an IBM/Epson/Oki or HP LaserJet Series II printer, selectable lat/lon grid intervals, disk command files, automatic control of antenna rotators with full 180 degree elevation, coverage swath display for weather sats, multiple range circles, automatic sat switching, real-time ground track display, and squint angle display.

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The package includes an editor program used to construct and modify sat/obs data base files. In addition, a program to update data base files from bulletin boards, complete source code for a compatible rotator and receiver control program and several other utilities are included.

Requires an IBM PC, PC/XT, PC/AT, or true compatible, an IBM Color/Graphics Monitor Adaptor or true compatible, optional but recommended 80x87 math coprocessor, minimum 512K RAM, DOS 2.0 or later, and either two 360K floppy drives or one 360K floppy and one hard drive; the programs are not copy protected.

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AMSAT-NA Operations Report

In this edition of the AMSAT-NA Operations report, I'm thinking out loud about some ways in which we could improve the end to end and beginning to end performance of our Amateur satellite movement.

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One policy that I've suggested and am working to implement is simply stated: "Build the ground stations, equipment, and procedures (software, etc.) at the same time as the satellites." This will, of course, allow fuller utilization of any satellite mission by having more ground stations ready and operating earlier in the satellite's lifetime.

The three issues that block progress along these lines are:

1) Satellite builders work in relatively small, highly motivated, tightly knit groups. Satellite users are more spread out in terms of temperament.

2) Building a ground station for a satellite that isn't working in orbit yet is risky. What if the satellite doesn't get into orbit? Of course, the satellite builders run this risk every time. Their project could go into the ocean every time one is launched. To be on the frontier with a ground station means sharing this risk.

3) Hams are, nearly by definition, NOT good communicators. This statement may come as a shock at first. What hams are good at is communications technology, the equipment and techniques of getting information from one place to another. They generally use the technology they have to transfer information about the technology itself or to nearly abstractly collect geographies (i.e. WAS, WAC, WAZ, DXCC, etc.), not particularly to discover the needs and motivations of others so as to be of genuine, personal service or support.

All of these concerns can be addressed. As an AMSAT-NA official, one of my roles is to keep the concept of building the whole satellite mission at one time (not just the orbiting part) out in front of everyone who wants to be involved in a satellite building project with AMSAT-NA. The experienced tell me that users are not interested in preparing for satellites that aren't up yet. I know that this statement is not universally true and that it is possible to change the outlook of some operators who are now reluctant to take such risks. It is among my greatest challenges to build and foster communications between people for whom it doesn't come too naturally and whose conception of their hobby, frankly, doesn't really involve helping and waiting for others to share the fun that they were wanting to have by themselves.

As an AMSAT-NA member, it is up to you to step forward and risk some dollars and some hours and to put up with a little pain when communications perhaps don't work out the first time. How can you do this? One way is to join the Command Station Development Program (contact WB9ANQ) and dialogue with the other guys there about how that project you're really interested in doing can fit into the team effort. This has worked splendidly for a number of people who might otherwise be off doing their own thing in a vacuum. It is, of course, not the optimum approach for everybody and there are other avenues of involvement that contribute just as well.

Whatever the case may be, the goal of making satellites useful as close to launch day as possible can't happen unless communications are enhanced and coordinated work is done by more people. I'll be looking for opportunities to play my role in this and I challenge you to do the same for your roles.

One job that needs to be done soon is development of some sort of 4800 baud modem so that AO-16 and LO-19 (and possibly WO-18) can be used at least part of the time at 4800 baud. If you're waiting for "them" to do this job and hand it to you, you may be waiting a long time. "Their" priorities may be to keep the Microsats on the air and to get the DOVE mission fully qualified. Then, "their" priorities may shift to the international Phase III-D project rather than the more pedestrian task of making Microsats work a little faster. Who will step up to the plate and take a swing at the 4800 baud modem project along with the associated technical (and social) challenges?

Now, thinking about good things that are already happening, how about the Alaska Net gateway now in place on AO-16? By the time you read this, NL7NC in Anchorage and KI6QE in California will have passed several hundred thousands of bytes of messages back and forth between Alaska and the lower 48, supplementing coverage and greatly improving throughput between the WØRLI style packet network in both places. Details on how this all works and how you can use the gateway are contained in an excellent article by John Lawson, NL7NC, elsewhere in this issue of the *AMSAT-NA Journal.*

I've also received messages via PACSATs indicating how much improved distribution of AMSAT News and Orbits and just regular packet mail is to South America now that we've started carrying them via AO-16 regularly. With the help of Dave Medley, KI6QE, and others, we plan to carry other general interest amateur radio bulletins (i.e. DX, propagation, ARRL, etc.) via the new satellites and encourage others to do the same. Here is another place where operators can help out.

I hope that the AKNET demonstration can be copied in many other cases to improve messaging and bulletin traffic to remote places and places where current packet service is not as fast as it could be.

To talk about these and other related issues, send me a message on AO-16 or check in to the AMSAT Operations Net, held three or four times a month on AO-13.

A final operational note: The PACSATs have enjoyed more early popularity than most of us who are closely involved in building the digital satellite service had envisioned. This is a good thing, but there is now more congestion on the uplinks than is good for anybody's throughput. One interim experimental measure being tried to reduce uplink contention is designed around the way that the protocol on the satellite handles multiple ground users. It is suggested that stations performing a download or directory request uplink on AO-16 channel D (145.960). Since downlink frames to these stations are interleaved, the uplink ack packets will also be interleaved and will not collide if ground TNC parameters are set correctly. The other uplink channels (145.900, 145.920, and 145.940) are reserved for uploads, which require an uncontested channel for good throughput. If this works out well, it may be possible to increase the maximum number of simultaneous PACSAT connections from four to five or more.

I hope my musings this month have provided you with some good direction and encouragement. I'm proud to count the people in the fraternity of Amateur satellite operators as friends and I look forward to communicating with each of you. ■

AMSAT APPLICATION NOTES:

You Don't Have To Key Them In Manually.

Automatically Updating Keplerian Elements Using QUIKTRAK 4.0

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At the 1990 AMSAT Space Symposium, Dick Campbell, N3FKV, AMSAT Operational Coordinator for Orbital Data Management, reported that, according to a recent informal survey, nearly half of the Amateur satellite community is still entering orbital data manually by inputting all of the numbers via the computer keyboard. This seems like an unusually large number of people. But judging from the numbers of questions we get via mail, phone calls or on the air, it seems that this is probably fairly accurate.

For those of you using the Apple II, C-64 or some of the older (and less expensive) computers for satellite tracking, you simply don't have any choice but to enter orbital data manually. But for those of you using a PC or compatible machine for satellite tracking, did you know that QT4.0 (QuikTrak Version 4.0) has a routine for automatic updating of Keplerian elements? Yep, it's true!

The documentation that comes with the program is a little scant on this subject. Basically it says to run QK (the update utility) and the instructions will appear on the screen. For those of us who aren't "real live computer whizzes," even these instructions may seem a little inadequate. In this article, we will try to explain how easy it is to update your Keplerian elements in QT4.0 using QK.EXE.

Let us assume you have obtained Keplerian data from some source and have it as an ASCII file on a disk. It would be advisable to put this file in a word processor and strip off any text or numerical data that is not normally part of the AMSAT or NASA format of Keplerian data. After editing the data file, be sure to save it as an ASCII file so that the word processor does not introduce any peculiar word processor related characters into the data file. Although stripping off extra text is not a necessity for QT4.0, the authors feel that it will lead to more predictable results.

For QK to run correctly, QK.EXE must be located in the same directory as KEPFILE and STNMFILE. This is an absolute necessity! The ASCII file containing your new Keplerian data may be located in a different directory, but the three above mentioned files must be in the same directory. For the examples below, let us assume that you called your ASCII file containing the new Keplerian elements KEP.DAT. Notice that it is legal to use a file extension as part of the ASCII data file name.

The following three examples show the most common command line entries to invoke QK.

Example 1

In this example, the first thing to do is to move KEP.DAT to the same directory as QK.EXE. Then select that directory using the DOS CD command. Then simply type

```
QK KEP.DAT
and hit the <RETURN> key.
```

Example 2

If KEP.DAT is located on a floppy disk to be used in the a: drive of your computer, the command is a little bit different. Again, select the directory that contains QK.EXE. Then type

```
QK a:KEP.DAT
and hit the <RETURN> key.
```

Example 3

Lets assume that KEP.DAT is located on the hard drive (c:) of your machine in a directory called ELEMENTS. After selecting the same directory that contains QK.EXE, you would type

```
QK c:\ELEMENTS\KEP.DAT
and hit the <RETURN> key.
```

After following one of the three examples shown above, you will be presented with an option select menu. The UPDATE options allow you to update the Keplerian data for the satellites that have the same name in both the KEP.DAT file and the KEPFILE and STNMFILE files. Note that the satellite names must match exactly, including upper/lower case letters. RELOAD options allow you to replace the first satellites in the KEPFILE and STNMFILE files with those that appear in the KEP.DAT file. UPDATE and RELOAD options are given for both AMSAT and NASA data formats. You simply use the up or down cursor keys to highlight the desired option and press <RETURN>. You should then see the names of the satellites scroll up from the bottom of the screen. When QK is finished, the DOS prompt will appear. It is amazing how fast the process is compared to the manual data entry method.

It should be noted that Keplerian data does not contain things like Mode Schedule, BLON, BLAT or Frequency. Thus, QK does not change this data. This data must be entered manually in QUIKTRAK using the DATA EDITOR option from the main menu. This type of data normally does not need to be updated very often, so manual entry of this data seems to be the appropriate method for updating.

Hopefully, this explanation of QK usage will encourage QT4.0 users to utilize the automatic Keplerian data update capability of the program. In terms of time efficiency, it is a very powerful feature that should not be overlooked. ■

SEDS AMSEP Project

(Continued from page 6)

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The New Microsat Software and the AEA PK-232

How to solve some problems and operate a successful PACSAT ground station with the PK-232 as the TNC.

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Operating the new Microsat ground station software with the AEA PK-232 can be a very frustrating experience. The reason for this is that this software was written for a TNC-2 and despite what you may have read, the PK-232 is not compatible with a TNC-2 in some important respects. For example, the initiation (handshake) procedure is quite different and consequently the PK-232 will not react directly to either PB or PG.

The ground station equipment consists of a PK-232 with 1989 firmware (this is important and will be referred to later) and a TAPR PSK modem with TAPR modem disconnect and DCD state machine. This latter is well worthwhile as it enables you to run with open squelch which in turn reduces the probability of collisions. The radio is a Yaesu FT-736R, all controlled with a very old (and slow) IBM PC AT.

In addition to the PG and PB software you will need PFH and PFHADD to assist you to prepare files for uploading and to extract information from downloaded files. To start a conversation with your PK-232 you will need a dumb terminal program such as PC-TALK or PROCOMM. I use the latter and the procedures I will outline refer to this software.

Before you do anything you must prepare the PG.CFG and PG.TNC files. The two files I use are as follows:-

PG.CFG

```
ao16access 30660
bbscall pacsat-12
bbcstcall pacsat-11
mycall ki6qe-0
port 2
speed 4800
graball 1
maxsel 30
```

PG.TNC

```
fulldup on
frack 6
maxframe 1
paclen 64
pactime 10
check 30
retry 10
dcdconn on
xon $00
xoff $00
start $00
stop $00
xflow off
txdelay 40
mcon off
mon 2
```

PG.CFG file is the same as for the TNC-2. Please note that I am running my PK-232 from computer port 2 at 4800 baud which has proved to be a good compromise. The PK-232 does not particularly like 9600 and actually appears to prefer 2400. Use either 2400 or 4800 whichever you prefer but remember which you have selected otherwise you will incur more frustration!

The dcdconn on is mandatory. The default value of this parameter is OFF and if you do not change this you will get a strange message about your DCD line being stuck on and this will lead to hours of head scratching looking for a hardware problem which does not exist.

The xon, xoff, start, stop and xflow changes simply remove other possibilities of unknown things happening which tend to lead to system lock-ups. They help with my system and I would suggest you leave them as I have unless you have a good reason to do otherwise. The PK-232 is prone to lock up the system for unexplained reasons and anything to reduce this possibility is well worthwhile.

You should also note that the PK-232 does not understand mall or mcom. These are to do with the monitoring facility and are replaced by mon 2. This results in the display of unconnected packets and information frames only. You can use different values for mon, depending on your personal preference. In the PG.CFG file there is a parameter maxsel 30. I have no idea what this does nor does the PK-232. I can find no reference to it in the TAPR TNC-2 literature which I have available. I have left it in, however, in case it has something directly to do with the software and not the TNC as such. These parameters are referred to in the instructions for PG.EXE 910206n.

With this done we can now start with PB.EXE. This software requires the PK-232 to be in KISS mode. PB will not do this for you so first bring up PROCOMM and set the COM port parameters at 4800,n,8,1 for the particular COM port you are using. Turn on the PK-232 and type two * after which the PK-232 will respond with the sign on message and a cmd prompt. If you have firmware in your PK-232 dated 1989, then all you have to do is type KISS ON and exit from PROCOMM (Alt-X) being sure to respond N to the HANG UP LINE? query. If you have an older PK-232 you have to do some more work. At the cmd prompt type the following:-

```
HPOLL OFF
PPERSIST ON
RAWHDLC ON
CONMODE TRANS
HOST ON
KISS ON
```

Then exit PROCOMM as before.

Now bring up PB and you are in business. I followed the instructions supplied with PB exactly, creating Directories called SEXE and PACSAT and including SEXE in the PATH command in the AUTOEXEC.BAT file. All the EXE files are in the SEXE Directory and the CFG and TNC files are in the PACSAT Directory. Start your program from the PACSAT Directory. All the files and directories from PACSAT will appear in this Directory.

To change from PB to PG is not as the writer of this software intended. First you must exit from PB (Q). Now, and this is most important, SWITCH YOUR TAPR PSK MODEM OFF. Failure to do this may lead to complete lock up of the system and require a cold boot. VERY ANNOYING AND TIME CONSUMING. Now bring up PROCOMM again. You have to do this because we now have to get the PK-232 out of KISS mode and into the TRANSPARENT mode and PG will not do that for you. (It will if you are using a TNC-2). Now hold down the Ctrl key and type C three times in the space of one second. Wait for about a second and the cmd prompt should appear. Don't be over anxious here. It takes an appreciable time from the three Ctrl-C's to the appearance of the cmd prompt. Now type TRANS, exit PROCOMM and bring

(Continued on page 30)

FO-20 PSK Modem Improvement for Microsat Use

Some users of my 1200 bps PSK modem have commented that data recovery with the Microsats is poor, difficult or in a few cases impossible. Personally I have no problem whatever with my standard modem and standard FT-736R, but persistent reports prompted further investigation.

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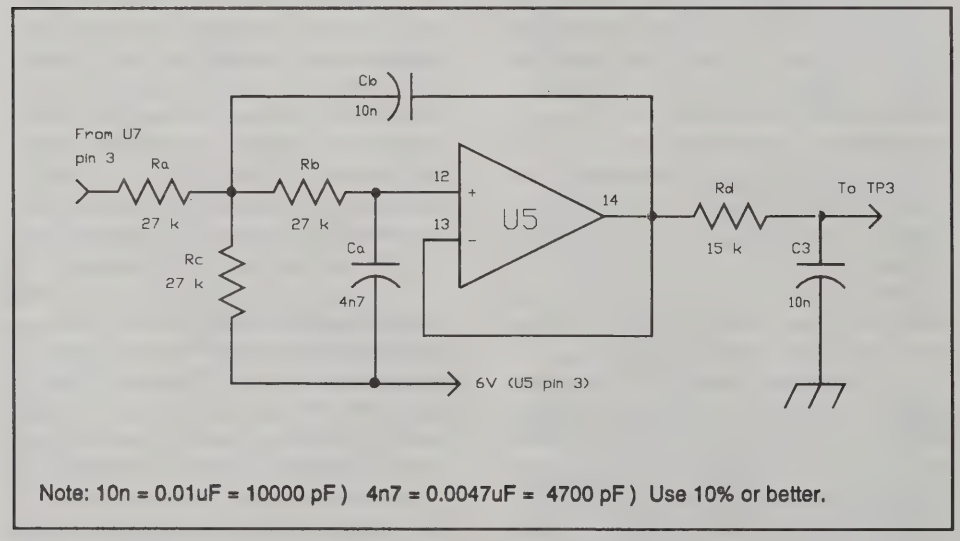
Fuji-Oscar 20 and AO-13 (400 bps) generate "pure" PSK. That is, the carrier phase is either 0 degrees or 180 degrees, and nothing else. Extensive investigation shows that all three Microsats (AO-16, WO-18 and LO-19) generate random phase noise. I (G3RUH) found peaks of +/-27 degrees on occasions with +/-10 degrees RMS scatter typical.

My modem, being designed "cold" and in wide circulation (1986) before FO-12 had even transmitted a packet, expected clean PSK. So its post phase detector (i.e. data) filter is an RC network R30/C3. This is entirely satisfactory for FO-20, but it hasn't really enough smoothing to deal comfortably with the Microsat phase jitter.

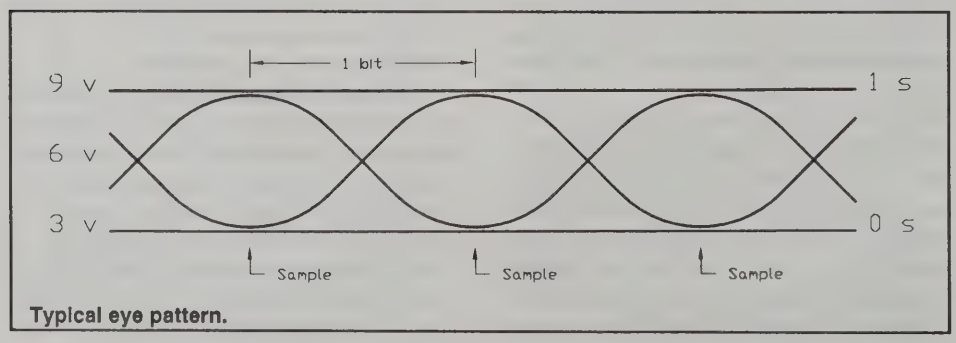
The cure is to upgrade the data filter. There is a spare op-amp on the board, so by the adding just 4 resistors and 2 capacitors, a 3-pole filter can quickly be implemented (15 minutes). The filter offers some 30 dB attenuation to the effects of excessive phase noise, and you'll get effortless 100% data recovery from PACSAT, WEBERSAT and LUSAT.

Application

This modification is for PCBs marked "JAS-1/FO-12 MODEM (C)1986 G3RUH", issues 1 & 2.



Note: 10n = 0.01uF = 10000 pF) 4n7 = 0.0047uF = 4700 pF) Use 10% or better.



Typical eye pattern.

Circuit

Note that the existing R30 is removed, and the input of this circuit is from its left-hand hole, close to the legend "VR2". The existing C3 remains and becomes part of the new filter. The circuit uses a spare section of op-amp U5 so only 6 components Ra,Rb,Rc,Rd,Ca,Cb are new.

Construction

Ra, Rb, Rc, Rd, Ca, Cb are fixed to the underside of the PCB. Pin 14 of U5 is the pin nearest the legend "U5", and don't forget to link pins 13 & 14. Make sure that components and leads cannot accidentally touch PCB tracks.

Test - the "EYE"

Tune in a satellite as normal. Set the oscilloscope to 2V/div vertical and timebase 0.2 ms/div. Trigger from TP4 (1200 Hz), and examine the waveform at TP3. You should see the characteristic "eye", with amplitude 6V pk-pk, centered on approximately 6V.

The TNC samples this waveform at the widest part of the eye. If it is above the mid-line, it detects a "1", if below a "0". So the quality and openness of this eye is a measure of detection robustness.

Don't Forget

Two points that are as important now as they ever were:

1. AUDIO CARRIER FREQUENCY. Make sure that you have the optimum audio carrier frequency. It'll be in the region of 1400-1700 Hz (at TP1). Lock the modem on to a satellite at the start of a pass when Doppler changes slowly. Look at the eye and VERY, VERY gently vary VR1. This will remotely auto-tune the radio up and down. Leave VR1 at the point where you judge the eye to be at its best; wide open and symmetric.

2. DETECTOR THRESHOLD. Input SSB radio noise to the decoder. Adjust VR2 for average mid-scale reading on the centre-zero tuning meter. Alternatively, set it for exactly 50% of the 12V supply. It should ideally be the same voltage as at the mid level of the eye.

Thanks

Special thanks to VK5AGR, VK5HI, VK5ZK and G4WFQ for acting as testers to validate these findings. ■

ICOM CI-V Satellite Transponder Software Interface

In the never ending search for cost effective alternatives for station automation, here is a home-grown project designed to reduce the number of hands required for satellite station operation and at the same time, reduce the swishing up and down the passband. — Ed.

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This project provides an alternative solution to purchasing commercially made units which permits slaving of two ICOM CI-V equipped radios. Implementation is done on a PC compatible using COM1 interfaced to an ICOM 275A and COM2 interfaced to an ICOM 475A. The only additional hardware required is a CI-V to RS-232 level converter interface and connecting cables (see Figure 1). The concept should be readily adaptable to the ICOM 271/471 and Kenwood 711/811 radios.

The advantages of this approach over the commercially available hardware approach are cost, easy split-frequency operation, memory programming, and flexibility. However there are a few disadvantages to this system. The first is a minor inconvenience in that the software approach utilizes two of your computer's COM ports which may be required at other times for your mouse, modem, or printer. Second, the program must run in the foreground, therefore, QuickTrack, InstantTrack, or any other tracking program cannot be running simultaneously. That's the price you pay for being cheap .... I mean cost conscious.

For successful satellite communication, you should be able to do the following:

(1) Have your transmitter and receiver on-frequency

(2) Have your antenna pointed at the bird

(3) Know the spacecraft attitude (aka: squint angle)

This program and the associated hardware takes care of Item 1. You can print off the tracking and squint angle information to tell you where to point your antenna as well as inform you as to when the optimal squint angle range occurs. If you are running the Kansas City Tracker, since it runs as a TSR (Terminate and Stay Resident) program, it will run in the background to point your antenna for you.

The source program is written in Microsoft QuickBasic ver 4.5 and thus available for both PCs and Macs. It may be possible to port it to QuickBasic for the Mac, however, particular care should be taken, especially in the serial port communication area, to see that the translation was successful. PC source code is provided for those who have QuickBasic and desire to tailor the program .

In my first attempt at this project, I attempted to use only one COM port. It took only minutes to determine that the single COM port approach required special software support. Whenever an asynchronous framing, overrun, or parity error would

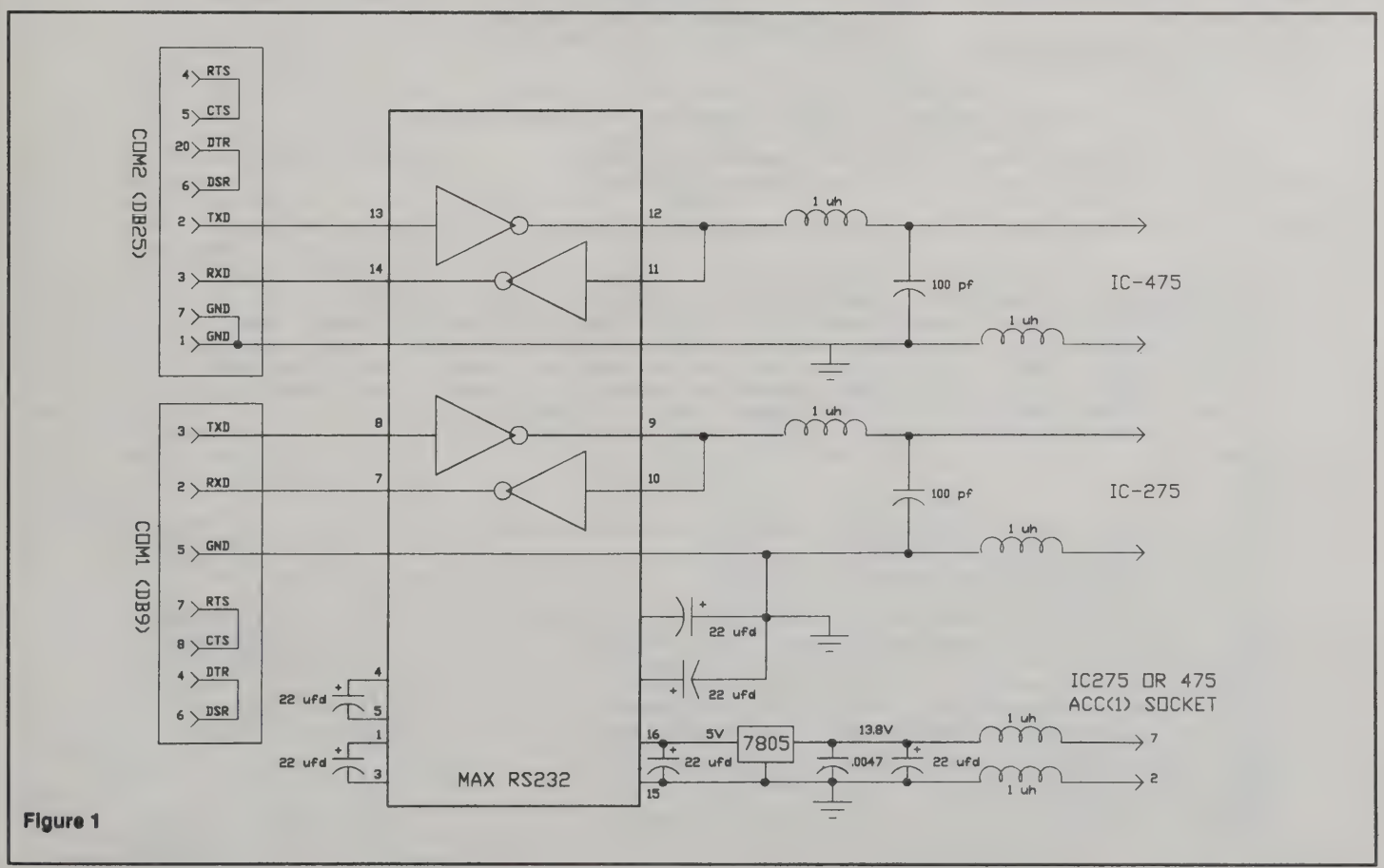

Figure 1

occur, due to multiple CI-V transmitters being on the line simultaneously, program execution would cease and lockup with an error message. The limited error handling capabilities of QuickBasic, compounded by my limited experience in PC programming of the COM ports, resulted in the use of two COM ports. Unfortunately, QuickBasic only supports COM1 and COM2 or I would have opted to use COM3 and COM4 to avoid the mouse, and modem support problems.

Program execution begins with the message display of Figure 2. While the message is displayed, memory channels are loaded with the data noted in the message. This is a convenience function and could be deleted or modified for the repeater frequencies in your area. Upon initialization of the memory channels the message of Figure 3 is displayed. The program defaults to tracking AO-13 Mode B. Any change in the receiver dial results in a corresponding correction in the transmitter based upon the current transponder offset. The transmitter frequency may be changed as desired without effecting the receiver frequency. Pressing the B key causes the transponder frequency to be reset to the sum of the VHF and UHF frequencies displayed and causes the UHF transmitter to track the VHF receiver. Pressing the J key causes the transponder frequency to be reset to the sum of the VHF and UHF frequencies displayed and causes the VHF transmitter to track the UHF receiver.

To change modes rapidly use the pre-stored frequencies in memory channels 1, 2 or 3 to enter the frequencies. Pressing the S key prompts the operator to enter an offset in kHz which maybe added, subtracted, or zeroed out from the transponder offset value. Pressing the Q key causes the program to terminate and returns you to the system level software. Pressing the U key unlocks the transceivers. Beacon levels can be rapidly checked by loading memory channel 10 or 13.

The program as written supports only Modes B and J, but could be readily expanded to other modes. The predecessor of this program post-processed the QuickTrak TRACK.DMP file to enter a Doppler correction. I found this version easier to work with. To compensate for Doppler changes simply re-tune the transmitter and press the B or J key. You will then be on frequency across the band until another Doppler shift adjustment is required.

Hopefully, the programming gurus will honor us guys who don't own YASEU FT-736Rs, with the service of integrating this CI-V function into the next version of QuikTrak or InstantTrack. Meanwhile, stop tuning up on frequency and annoying others. Use this program and stay off KL7GRF's list. (Just kidding John.)

Figure 2 — The program is preloaded with the following data:

Memory 1	AO-13/B center freq/ssb
Memory 2	AO-13/J center freq/ssb
Memory 3	AO-10 center freq/ssb
Memory 4	Reserved for current frequency
Memory 5-7	Weather Channels
Memory 10	AO-10 Beacon/cw
Memory 13	AO-13 Beacon/cw
Memory 20-23	Local Repeaters

Figure 3

VHF	UHF	OFFSET	MODE	DATE	LOCAL TIME
145.900000	435.492118	0.000	B	04-09-1991	21:50:26

press B key to reset transponder freq and track vhf rcvr
press J key to reset transponder freq and track uhf rcvr
press S key to reset transmitter offset
press Q key to quit
press U key to unlock vhf - uhf transceivers

```
ICOM CI-V Satellite Transponder Rcvr-Xmitter Tracker

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WA4VOC
ALL COMMERCIAL RIGHTS RESERVED

INIT:   DEFINT I-J
        DEF FNREQF$ (RADIO$) = CHR$(254) + CHR$(254) + RADIO$ + CHR$(241) + CHR$(3) + CHR$(253)
        DEF FNFREQ$ (RADIO$, FREQ$) = CHR$(254) + CHR$(254) + RADIO$ + CHR$(241) + CHR$(5) + FREQ$ + CHR$(253)
        DEF FNMODE$ (RADIO$, MODE$) = CHR$(254) + CHR$(254) + RADIO$ + CHR$(241) + CHR$(6) + MODE$ + CHR$(253)
        DEF FNVFO$ (RADIO$, VFO$) = CHR$(254) + CHR$(254) + RADIO$ + CHR$(241) + CHR$(7) + VFO$ + CHR$(253)
        DEF FNMCH$ (RADIO$, MCH$) = CHR$(254) + CHR$(254) + RADIO$ + CHR$(241) + CHR$(8) + MCH$ + CHR$(253)
        DEF FNMW$ (RADIO$) = CHR$(254) + CHR$(254) + RADIO$ + CHR$(241) + CHR$(9) + CHR$(253)
        REM++++++++++++++++++++++++++++++MSG++++++++++++++++++++++++++++++++
        SCREEN 0, 1
        COLOR 7, 9
        CLS
        LOCATE 3, 14: PRINT "ICOM CI-V satellite transponder rcvr-xmitter tracker"
        LOCATE 5, 30: PRINT "COPYRIGHT 9 April 1991"
        LOCATE 6, 33: PRINT "JAMES R. SCHMIDT"
        LOCATE 7, 38: PRINT "WA4VOC"
        LOCATE 8, 25: PRINT "ALL COMMERCIAL RIGHTS RESERVED"
        LOCATE 10, 18: PRINT "The program is preloading the following data"
        LOCATE 12, 23: PRINT "Memory  1     AO-13/B center freq/ssb"
        LOCATE 13, 23: PRINT "Memory  2     AO-13/J center freq/ssb"
        LOCATE 14, 23: PRINT "Memory  3     AO-10   center freq/ssb"
        LOCATE 15, 23: PRINT "Memory  4     Reserved for current frequency"
        LOCATE 16, 23: PRINT "Memory  5-7   Weather Channels"
        LOCATE 17, 23: PRINT "Memory  10    AO-10   Beacon/cw"
        LOCATE 18, 23: PRINT "Memory  13    AO-13   Beacon/cw"
        LOCATE 19, 23: PRINT "Memory  20-33 Local Repeaters"
        REM++++++++++++++++++++++++++INITALIZE RADIOS++++++++++++++++++++++++++
```

```
        REM SETUP WEATHER CHANNELS
        VHF$ = CHR$(16): REM ICOM-
275A ADDR
        UHF$ = CHR$(20): REM ICOM-
475A ADDR
        VFO$ = CHR$(1):  REM VFO B
        MCH$ = CHR$(5)
        VHF# = 162.4#: UHF# =
435.651#
        VHFMODE$ = CHR$(5): REM FM
        UHFMODE$ = CHR$(5): REM FM
        GOSUB SEND
        MCH$ = CHR$(6)
        VHF# = 162.475#: UHF# =
435.651#
        GOSUB SEND
        MCH$ = CHR$(7)
        VHF# = 162.55#: UHF# =
435.651#
        GOSUB SEND
        REM SETUP REPEATERS
        MCH$ = CHR$(32): REM MEM CHN
20
        VHF# = 145.21#: UHF# = 444.1#
        GOSUB SEND
        MCH$ = CHR$(33)
        VHF# = 146.61#: UHF# = 444.2#
        GOSUB SEND
        MCH$ = CHR$(34)
        VHF# = 146.67#: UHF# = 444.5#
        GOSUB SEND
        MCH$ = CHR$(35)
        VHF# = 146.7#: UHF# = 444.9#
        GOSUB SEND
        MCH$ = CHR$(36)
        VHF# = 146.76#: UHF# = 443.9#
        GOSUB SEND
        MCH$ = CHR$(37)
        VHF# = 146.88#: UHF# =
444.35#
        GOSUB SEND
        MCH$ = CHR$(38)
        VHF# = 146.94#: UHF# = 444.9#
        GOSUB SEND
        MCH$ = CHR$(39)
        VHF# = 147.03#: UHF# = 443.1#
        GOSUB SEND
        MCH$ = CHR$(40)
        VHF# = 147#: UHF# = 442.125#
        GOSUB SEND
        MCH$ = CHR$(41)
        VHF# = 147.07#: UHF# = 442.5#
        GOSUB SEND
        MCH$ = CHR$(48): REM MEMCH 30
        VHF# = 147.12#: UHF# =
442.65#
        GOSUB SEND
        MCH$ = CHR$(49)
        VHF# = 147.18#: UHF# =
443.25#
        GOSUB SEND
        MCH$ = CHR$(50)
        VHF# = 147.27#: UHF# =
443.75#
        GOSUB SEND
        MCH$ = CHR$(51)
        VHF# = 147.36#: UHF# =
443.95#
        GOSUB SEND
        MCH$ = CHR$(52)
        VHF# = 147.39#: UHF# = 444#
        GOSUB SEND
        REM SETUP AO-13 BEACONS
        MCH$ = CHR$(19): REM PACKED
BCD 13
        VHF# = 145.812#: UHF# =
435.651#
        VHFMODE$ = CHR$(3): REM CW
        UHFMODE$ = CHR$(3): REM CW
        GOSUB SEND
        REM SETUP AO-10 BEACON
        MCH$ = CHR$(16): REM PACKED BCD 10
        VHF# = 145.81#
        GOSUB SEND
        REM SETUP AO-13/J
        MCH$ = CHR$(2): REM MEMORY CHANNEL 2
        VHF# = 144.453#: UHF# = 435.96#
        VHFMODE$ = CHR$(0): REM LSB
        UHFMODE$ = CHR$(1): REM USB
        GOSUB SEND
        REM SETUP AO-10/B
        VFO$ = CHR$(0): REM VFO A
        MCH$ = CHR$(3)
        VHF# = 145.9#: UHF# = 435.1047#
        VHFMODE$ = CHR$(1): REM USB
        UHFMODE$ = CHR$(0): REM LSB
        GOSUB SEND
        REM SETUP AO-13/B
        MCH$ = CHR$(1)
        UHF# = 435.492118#
        GOSUB SEND
        MCH$ = CHR$(4): REM MEMORY CHANNEL 2
        V4$ = FNMCH$(VHF$, MCH$)
        U4$ = FNMCH$(UHF$, MCH$)
        OPEN "COM1:1200,N,8,1" FOR OUTPUT AS #1
        PRINT #1, V4$
        CLOSE #1
        OPEN "COM2:1200,N,8,1" FOR OUTPUT AS #2
        PRINT #2, U4$
        CLOSE #2
        MODE$ = "B"
        PRIORVHF# = VHF#
        PRIORUHF# = UHF#
        OFFSET# = 0
        TRANSPONDER# = VHF# + UHF#
        V6$ = FNREQF$(VHF$)
        U6$ = FNREQF$(UHF$)
        CLS
        REM++++++++++++++++++++++++++++++MAIN++++++++++++++++++++++++++++++
        PASS = 0: DOPPLER# = 0#: PRIORDOPPLER# = 0#: DOPPLERI# = 0#
        TIMEZONE = 41
MAIN0:  IF PASS <> 0 THEN GOTO MAIN1
        PASS = 1
MAIN1:  LOCATE 1, 1: PRINT "VHF"; TAB(13); "UHF"; TAB(26); "OFFSET"; TAB(43);
"MODE"; TAB(52); "DATE"; TAB(65); "LOCAL TIME"
        LOCATE 2, 1: PRINT USING "###.######"; VHF#; TAB(13); UHF#;
        LOCATE 2, 26: PRINT USING "#.###"; OFFSET#;
        LOCATE 2, 43: PRINT MODE$; TAB(52); DATE$; TAB(65); TIME$
        LOCATE 10, 12: PRINT "press B key to reset transponder freq and track vhf
rcvr"
        LOCATE 11, 12: PRINT "press J key to reset transponder freq and track uhf
rcvr"
        LOCATE 12, 12: PRINT "press S key to reset transmitter offset"
        LOCATE 13, 12: PRINT "press Q key to quit"
        LOCATE 14, 12: PRINT "press U key to unlock vhf - uhf transceivers"
        IF FLAGQT40$ = "N" THEN GOTO MAIN11
        LOCATE 6, 1: PRINT HEADER1$
        LOCATE 7, 2: PRINT HEADER2$
        LOCATE 8, 1: PRINT TRACK$
MAIN11: Z$ = INKEY$
        IF LEN(Z$) = 0 THEN GOTO MAIN3
        Z$ = LEFT$(Z$, 1)
        IF Z$ = "B" OR Z$ = "b" THEN MODE$ = "B"
        IF Z$ = "J" OR Z$ = "j" THEN MODE$ = "J"
        IF Z$ = "Q" OR Z$ = "q" THEN END
        IF Z$ = "S" OR Z$ = "s" THEN GOTO MAIN7
        IF Z$ = "U" OR Z$ = "u" THEN GOTO MAIN8
MAIN2:  OPEN "COM1:1200,N,8,1" FOR RANDOM AS #1
        PRINT #1, V6$
        GOSUB SEQ0
        CLOSE #1
        PRIORVHF# = VHF#
        OPEN "COM2:1200,N,8,1" FOR RANDOM AS #1
        PRINT #1, U6$
        GOSUB SEQ0
        CLOSE #1
        PRIORUHF# = UHF#
        TRANSPONDER# = VHF# + UHF#
```

```
        GOTO MAIN0
MAIN3:  IF MODE$ = "B" THEN GOTO MAIN5
        IF MODE$ = "J" THEN GOTO MAIN4
        IF MODE$ = "U" THEN GOTO MAIN6
MAIN4:  OPEN "COM2:1200,N,8,1" FOR INPUT AS #1
        GOSUB SEQ0
        CLOSE #1
        IF PRIORUHF# = UHF# THEN GOTO MAIN0
        PRIORUHF# = UHF#
MAIN41: VHF# = TRANSPONDER# - (OFFSET# / 1000) - UHF#
        T# = VHF#
        GOSUB FREQS
        V2$ = FNFREQ$(VHF$, T$)
        OPEN "COM1:1200,N,8,1" FOR OUTPUT AS #2
        PRINT #2, V2$
        CLOSE #2
        GOTO MAIN0
MAIN5:  OPEN "COM1:1200,N,8,1" FOR INPUT AS #1
        GOSUB SEQ0
        CLOSE #1
        IF PRIORVHF# = VHF# THEN GOTO MAIN0
        PRIORVHF# = VHF#
MAIN51: UHF# = TRANSPONDER# - (OFFSET# / 1000) - VHF#
        T# = UHF#
        GOSUB FREQS
        U2$ = FNFREQ$(UHF$, T$)
        OPEN "COM2:1200,N,8,1" FOR OUTPUT AS #2
        PRINT #2, U2$
        CLOSE #2
        GOTO MAIN0
MAIN6:  OPEN "COM1:1200,N,8,1" FOR INPUT AS #1
        GOSUB SEQ0
        CLOSE #1
        OPEN "COM2:1200,N,8,1" FOR INPUT AS #1
        GOSUB SEQ0
        CLOSE #1
        GOTO MAIN0
MAIN7:  LOCATE 4, 1: INPUT "OFFSET ( #.### KHz):", OFFSET#
        LOCATE 4, 1: PRINT "                                    "
        IF MODE$ = "J" THEN GOTO MAIN41 ELSE GOTO MAIN51
MAIN8:  MODE$ = "U": GOTO MAIN0
        REM++++++++++++++++++++++++++++++SUBROUTINES++++++++++++++++++++++++++++++
SEND:   T# = VHF#
        GOSUB FREQS
        V1$ = FNVFO$(VHF$, VFO$)
        V2$ = FNFREQ$(VHF$, T$)
        V3$ = FNMODE$(VHF$, VHFMODE$)
        V4$ = FNMCH$(VHF$, MCH$)
        V5$ = FNMW$(VHF$)
        OPEN "COM1:1200,N,8,1" FOR OUTPUT AS #1
        PRINT #1, V1$;
        PRINT #1, V2$;
        PRINT #1, V3$;
        PRINT #1, V4$;
        PRINT #1, V5$;
        CLOSE #1
SEND2:  T# = UHF#
        GOSUB FREQS
        U1$ = FNVFO$(UHF$, VFO$)
        U2$ = FNFREQ$(UHF$, T$)
        U3$ = FNMODE$(UHF$, UHFMODE$)
        U4$ = FNMCH$(UHF$, MCH$)
        U5$ = FNMW$(UHF$)
        OPEN "COM2:1200,N,8,1" FOR OUTPUT AS #2
        PRINT #2, U1$;
        PRINT #2, U2$;
        PRINT #2, U3$;
        PRINT #2, U4$;
        PRINT #2, U5$;
        CLOSE #2
SEND3:  RETURN
FREQS:  REM CONVERT FREQUENCY TO CI-V FREQ STRING
        I1 = INT(T# / 1000)
        T1# = T# - I1 * 1000
        I2 = INT(T1# / 100)
        T2# = T1# - I2 * 100
        I3 = INT(T2# / 10)
        T3# = T2# - I3 * 10
        I4 = INT(T3#)
```

AMSAT Headquarters has the Satellite Operating Software you need. For a complete list, see the *AMSAT Journal*, July, 1990, page 14 and this issue page 22.

A Beginners Guide to OSCAR 13, by Keith Berglund, WB5ZDP, is a step-by-step guide to getting started on OSCAR 13. $7 in the U.S., $8 in Canada and Mexico, $10 elsewhere.

The Satellite Experimenter's Handbook, by Dr. Marty Davidoff, K2UBC, is the finest book written for the Radio Amateur. $22 in the U.S., $25 in Canada, $30 in South America and Europe, and $35 elsewhere.

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```
        T4! = (T3# - I4) * 1000000!
        I5 = INT(T4! / 100000!)
        T5! = T4! - I5 * 100000!
        I6 = INT(T5! / 10000!)
        T6! = T5! - I6 * 10000!
        I7 = INT(T6! / 1000!)
        T7! = T6! - I7 * 1000!
        I8 = INT(T7! / 100!)
        T8! = T7! - I8 * 100!
        I9 = INT(T8! / 10!)
        T9! = T8! - I9 * 10!
        I10 = INT(T9!)
        J1 = I1 * 16! + I2: J2 = I3 * 16! + I4: J3 = I5 * 16! +
             I6: J4 = I7 * 16! + I8: J5 = I9 * 16! + I10
        T$ = CHR$(J5) + CHR$(J4) + CHR$(J3) + CHR$(J2) +
CHR$(J1)
        RETURN
SEQ0:   IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ1
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ1:   Z$ = INPUT$(1, #1): Z = ASC(Z$): REM LEAD-IN CODE
        IF Z <> 254 THEN GOTO SEQ0
        IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ0
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ2:   Z$ = INPUT$(1, #1): Z = ASC(Z$): REM LEAD-IN CODE
        IF Z <> 254 THEN GOTO SEQ0
        IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ2
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ3:   Z$ = INPUT$(1, #1): Z0 = ASC(Z$): REM RCVR ADDR
        IF Z0 = 0 THEN GOTO SEQ31
        IF Z0 = 241 THEN GOTO SEQ31 ELSE GOTO SEQ0
SEQ31:  IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ2
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ4:   Z1$ = INPUT$(1, #1): Z = ASC(Z$): REM XMIT ADDR
        IF Z1$ = VHF$ THEN GOTO SEQ41
        IF Z1$ = UHF$ THEN GOTO SEQ41 ELSE GOTO SEQ0
SEQ41:  IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ5
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ5:   Z$ = INPUT$(1, #1): Z = ASC(Z$): REM FREQ CTRL CODE
        IF Z = 0 AND Z0 = 0 THEN GOTO SEQ51
        IF Z = 3 AND Z0 = 241 THEN GOTO SEQ51 ELSE GOTO SEQ0
SEQ51:  IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ6
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ6:   F1$ = INPUT$(1, #1): REM READ 1ST CHAR (lsb)
        IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ7
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ7:   F2$ = INPUT$(1, #1): REM READ 2ND CHAR
        IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ8
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ8:   F3$ = INPUT$(1, #1): REM READ 3RD CHAR
        IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ9
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ9:   F4$ = INPUT$(1, #1): REM READ 4TH CHAR
        IF EOF(1) THEN GOSUB X6 ELSE GOTO SEQ10
        IF TIMEOUT$ = "Y" THEN GOTO SEQ18
SEQ10:  F5$ = INPUT$(1, #1): REM READ 5TH CHAR (msb)
        F0 = ASC(F1$): F1 = 0: F2 = ASC(F2$): F3 = 0: F4 =
ASC(F3$): F5 = 0: F6 = ASC(F4$): F7 = 0: F8 = ASC(F5$): F9 = 0
SEQ11:  IF F8 < 16 THEN GOTO SEQ12
        F8 = F8 - 16: F9 = F9 + 1: GOTO SEQ11
SEQ12:  IF F6 < 16 THEN GOTO SEQ13
        F6 = F6 - 16: F7 = F7 + 1: GOTO SEQ12
SEQ13:  IF F4 < 16 THEN GOTO SEQ14
        F4 = F4 - 16: F5 = F5 + 1: GOTO SEQ13
SEQ14:  IF F2 < 16 THEN GOTO SEQ15
        F2 = F2 - 16: F3 = F3 + 1: GOTO SEQ14
SEQ15:  IF F0 < 16 THEN GOTO SEQ16
        F0 = F0 - 16: F1 = F1 + 1: GOTO SEQ15
SEQ16:  FREQ# = F9 * 1000 + F8 * 100 + F7 * 10 + F6 + F5 /
10 + F4 / 100 + F3 / 1000 + F2 / 10000 + F1 / 100000
        IF Z1$ = VHF$ THEN VHF# = FREQ# ELSE UHF# = FREQ#
SEQ18:  RETURN
X6:     FOR I = 1 TO 30000
        IF NOT EOF(1) THEN I = 31000
        NEXT I
        IF I > 31000 THEN TIMEOUT$ = "N" ELSE TIMEOUT$ = "Y"
        RETURN
```

■

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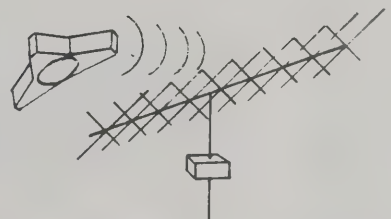

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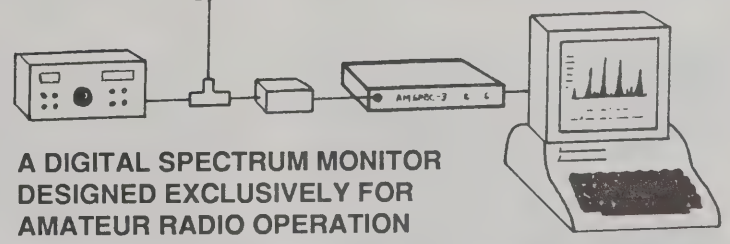

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AMSAT News

Sixth Annual AMSAT-UK Colloquium Announced

AMSAT-UK is sponsoring a symposium focused on all OSCAR satellites and digital communications. Questions & Answer sessions with various Amateur Satellite experts are planned as are tours of the UoSat command station. As in years past, the University of Surrey will be the meeting place for this colloquium. For more details on the symposium, contact: Ron Broadbent, G3AAJ, 94 Herongate Road, Wanstead Park, London E12 5EQ England. Tel: 44-81-989-6741 (From the U.S.) Fax: 44-81-989-3430 (24 Hours)

AMSAT Board of Directors Nominations

Nominations are sought for the AMSAT Board of Directors. Directors are elected by the membership for a two-year term. Any member society or group of five current members can nominate a member to run for the position.

This year there are four seats to be filled. Those directors whose seats are up for election are Jan King, W3GEY, Andy MacAllister, WA5ZIB, Bob McGwier, N4HY and Bill Tynan, W3XO.

All nominations should be sent to: AMSAT BOD Nominations, 850 Sligo Ave. #600, Silver Spring, MD 20910. They should arrive no later than June 15, 1991. ■

Recent DXCC-EME #1 recipient, W5UN, Dave Blaschke, receives a plaque from Junior DeCastro, PY2BJO, in recognition of Dave's work to rescue DO-17.

Satellite Orbital Elements

By Eric Rosenberg, WD3Q
c/o AMSAT Hq.

We are presenting the Keplerian Elements for Amateur satellites in the 2-line NASA format. The reason for this is to conserve space in the *Journal* and present all the elements on a single page.

NASA 2-line elements as shown below are available electronically, and can be read directly into QuikTrak v4.0, and InstantTrack v1.0—both available from the AMSAT office.

Should you want to see a specific satellite's set of elements in long form that you have been used to using, you can either translate them manually using the key below, or run the 2-line element set through a program written by Bob McGwier, N4HY, called ELETRANS.EXE which is available on the AMSAT (DRIG) BBS and on CompuServe.

The NASA 2-line element sets themselves are available from a variety of sources, including AMSAT (DRIG) BBS, CompuServe, The Celestial BBS in Fairborn, Ohio and the Internet.

Data for each satellite consists of three lines in a fixed format shown in Table 1, using AMSAT-OSCAR 13 as an example.

(Continued on page 30)

Table 1: Sample Element Set for AMSAT-OSCAR 13

```
AO-13
1  19216U 88 51 B 90 21.40340404 -.00000075 00000-0 99999-4 0 704
2  19216 57.1171 172.3126 6876271 219.5193 61.5621 2.09701111 12323
```


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14 regular paid Column Editors allow "SPEC-COM" to cover ALL modes of Specialized Communications for Radio Amateurs! Modes like FSTV SSTV FAX RTTY AMTOR PACKET WEFAX TVRO OSCAR SATELLITES MICROWAVE COMPUTERS AND SHORTWAVE RADIO. Joe Holman KA7LDN of Redman, WA, AMSAT's Northwest Area Regional Coordinator writes a regular OSCAR and NASA News column each issue. Greg Mengel KA6DPV and Fred Sharp W8ASF Cover Weather Satellites and Slow-Scan TV in great detail. "SPEC-COM" has all the latest Keplerian Elements on all the birds (not just OSCAR), NASA Space Shuttle News, ATV & Packet Balloon & Rocket Launch information and behind the scenes preparations! Our Electronic Cottage National Telephone BBS supports all of these subjects and has been on-line for over a year now. Dial it up and "see" what we have to offer! [300-2400 baud, 8-N-1] We also support "QSO AMATEUR RADIO" programing on TVRO GTE Satellite - Spacenet 1 Channel 15 (120 degrees)!

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Satellite Image Acquisition for the Amateur

Reprinted from the Proceedings *of the AMSAT Symposium.*

By Jeff Wallach, N5ITU
Chairman
Dallas Remote Imaging Group

A new and exciting facet of Amateur Radio that has been continually evolving over the past several years is that of satellite image acquisition and digital processing. Satellite enthusiasts have long been fascinated by the concept of receiving imagery from various platforms orbiting the Earth, displaying pictures in real-time mode, and digital+ processing and enhancing this imagery on their home computers. APT and WEFAX weather satellite images are now being received by many thousands of Amateurs around the world. With the recent launch of the OSCAR Microsat constellation, and the CCD color camera capabilities of the WEBERSAT platform, a renewed interest in satellite imagery and interpretation has arisen in the Amateur community. Adding to this excitement is the recent introduction of a low cost, super-high resolution HRPT (High Resolution Picture Transmission) weather satellite image system for the IBM PC bus developed by Dr. John DuBois and Ed Murashie. This exponential growth in the capabilities of the "Amateur" to receive imagery from space and digitally process the telemetry in real time on personal computers has generated both excitement and a critical need for information on 'how to get started'.

This treatise will provide a solid foundation in the basics of satellite image acquisition and processing. Weather satellite APT, WEFAX, HRPT, and WEBERSAT downlink protocols will be discussed, along with basic ground station and computer requirements that are logically constructed to bring the AMSAT satellite operator from ground zero to a fully operational station with professional capabilities. At this juncture, it is very important to point out that the majority of AMSAT members ALREADY have the basic station equipment required for satellite image reception and processing. Satellite stations currently working the OSCAR 13 and Microsats with two meter omnidirectional or beam antennas, preamp, two meter transceiver or scanning receiver, personal computer, packet terminal node controller (TNC), and satellite prediction software may upgrade their stations (at a fairly low incremental cost) for weather satellite and WEBERSAT imagery. Of primary importance will be the resolution capabilities of personal computer display system and hard disk storage availability. Hardware and software requirements for specific satellite imaging platforms will now be discussed in greater detail.

Satellite	Catalog #	Frequency (MHz)
NOAA 9	15427	137.620
NOAA 10	16969	137.500
NOAA 11	19531	137.620
METEOR 2-16	18312	137.850
METEOR 2-17	18820	137.300
METEOR 2-18	19851	137.300
METEOR 3-2	19336	137.300
METEOR 3-3	20305	137.850
METEOR 2-19	20670	137.850
FENG YUN 1-2	20788	137.795

Fig.1 — The frequency and NORAD catalog number of the currently active polar orbiting meteorological satellites.

Weather Satellite APT Imagery

The United States (NOAA), Soviet Union (Meteor), and most recently China (Feng Yun 1-2) operate polar orbiting weather satellites that transmit Automatic Picture Transmission (APT) weather images in real time format that may be received and reproduced by relatively inexpensive ground station equipment. The APT imagery is transmitted in the VHF band from 137 MHz to 138 MHz FM. The FM signal contains a subcarrier, the video image itself, as a 2400 Hz tone which is Amplitude Modulated (AM) to correspond to the light and dark areas of the Earth as detected from the visible and infrared (IR) sensors on the polar orbiting platform. Fig. 1 details the frequency and NORAD catalog number of the currently active polar orbiting meteorological satellites.

The higher amplitude component of the 2400 Hz tone represents the lighter portions of the Earth image, while the lower amplitude represents the darkest areas of the image. Intermediate amplitudes represent the shades of grey scale needed to produce the complete image of the Earth. The APT signal is thus an ANALOG format. This analog signal is actually derived from original digital data of the Advanced Very High Resolution Radiometer (AVHRR) instrument on the NOAA and Chinese weather satellites. The APT signal is transmitted continuously by all of the polar orbiting weather satellites. This results in a strip of image as long as the transmission is received by the ground station and is about 2200 km wide at an altitude of 870 km. A typical 14 minute pass would result in a continuous image approximately 5800 km long, and ends when the satellite signal is blocked as it crosses over the horizon relative to the specific ground station (loss of signal).

RF Receiving Equipment

OSCAR satellite operators essentially have the basic equipment necessary to receive the APT VHF downlink signal. Commercial receivers specifically designed for weather satellite reception, or scanning receivers covering the 137 MHz to 138 MHz range will work just fine. The IF bandwidth should optimally be 40 kHz, but even the wideband FM (150 kHz) IF bandwidth of popular scanners will result in an acceptable image if a full quieting signal is presented to the receiver. Two meter omnidirectional antennas or beams, 145 MHz GasFet preamps, and low-loss coax cable will provide outstanding APT imagery. This author routinely uses two meter KLM OSCAR beams, 145 MHz GasFet preamps with the 137 MHz receiver and obtains exquisite

visible and infrared images of the Earth, several times a day, from 870 km in space! These images are downlinked from U.S., Soviet, and Chinese APT imaging satellites. Thus, an operational OSCAR satellite station is easily adapted to receive the VHF weather satellite signals. Once the signal is received, the 2400 Hz amplitude modulated tone needs to be converted to a digital format and displayed as a visible image consisting of multiple shades of greyscale. This leads us to a discussion of the actual APT data format.

The analog APT image produced by NOAA and Chinese polar orbiting platforms (Soviet Meteor slightly different) is actually a derivative of AVHRR digital data containing two images and corresponding calibration and telemetry data. The two images are selected by ground control stations for APT from the five possible spectral bands provided by the AVHRR imaging instrument (Soviet Meteor satellites only transmit a single visible image or near infrared without the higher digital format). The spectral ranges detected by the AVHRR are as follows:

Channel	1	0.58-0.68uM	(visible)
	2	0.72-1.10uM	(near IR)
	3	3.55-3.93uM	(thermal IR)
	4	10.3-11.3uM	(thermal IR)
	5	11.5-12.5uM	(thermal IR)

Each video scan line is 0.5 seconds in length, containing two equal components. Each 0.25 second segment contains:

1. Specific synch pulse (832 Hz IR, 1040 Hz visible)

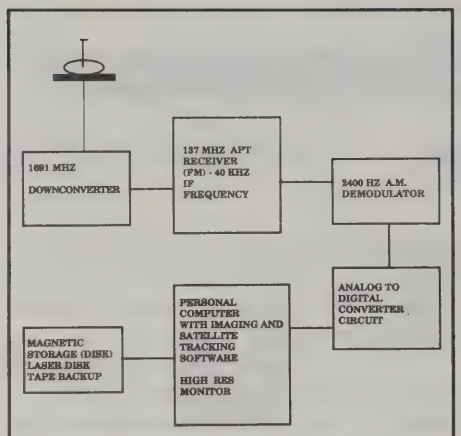

Fig.2 — Basic components of an APT/WEFAX Digital imagery ground station with image enhancement and storage capabilities.

2. Space data with 1 minute timing marks (NOAA 11 calibrated to WWV time signal)

3. Earth imagery from a selected AVHRR spectral channel

4. A telemetry frame segment

The 120 line per minute (LPM) image on NOAA satellites usually contains video from AVHRR visible Channel 1 and IR channel 4 during daylight passes. At night channel 2 and channel 5 typically are present. The newest Soviet Meteor birds transmit a single 120 lpm visible image during daylight passes, and a single 120 lpm near IR image at night. The Chinese FY 1-2 satellite is currently transmitting two visible channels during daylight, and no imagery (just greyscale and minute marks) during nighttime passes. Apparently the IR detector (if present) has not yet been commanded on.

Image Display Equipment

In order to display the APT image, the analog FM signal must be demodulated to remove the 2400 Hz subcarrier, then have the demodulated signal digitized by an analog to digital converter which changes the analog voltage into a discrete digital value. The 8 bit APT data can then be displayed as pixel elements on a monitor with one of 256 levels of greyscale, corresponding to the original brightness of the weather satellite image. This process of demodulation and A-D conversion is most often done by a personal computer adapter card with AM demodulator, proper filtering, and 8 bit A-D converter chip all on a single circuit board. This card may either be connected to the 8 bit parallel printer port (available on almost all PC's), or inserted directly into a slot on the PC bus architecture. Software will provide the proper 120 lpm scanning and positioning of the pixels on the monitor screen.

Once the 137 MHz signal is received, the audio tones are simply fed from the receiver speaker jack into the input jack on the AM demodulator board. The radio volume control can adjust the contrast of the incoming image. Fig. 2 represents a typical APT ground station including antenna, receiver, AM demodulator board,

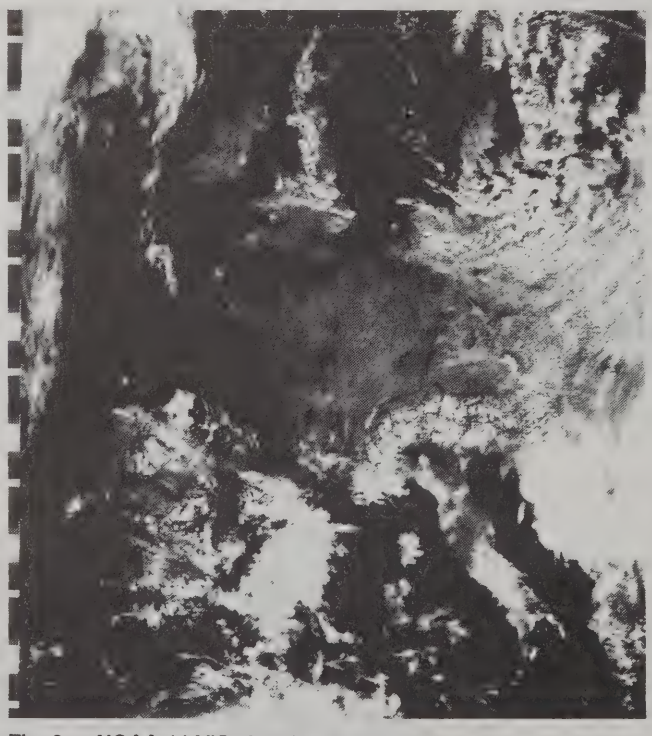

Fig. 3 — NOAA-11 VIS showing Europe.

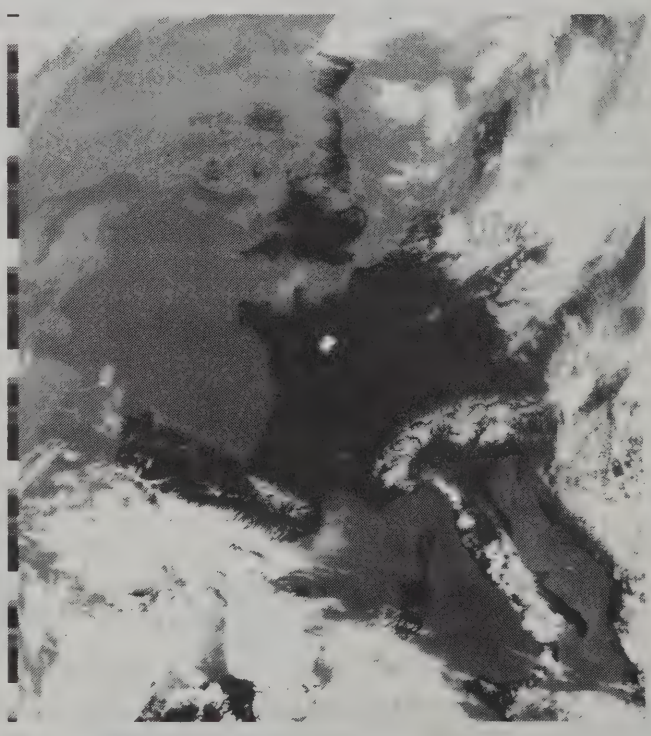

Fig. 4 — NOAA-11 IR showing Europe.

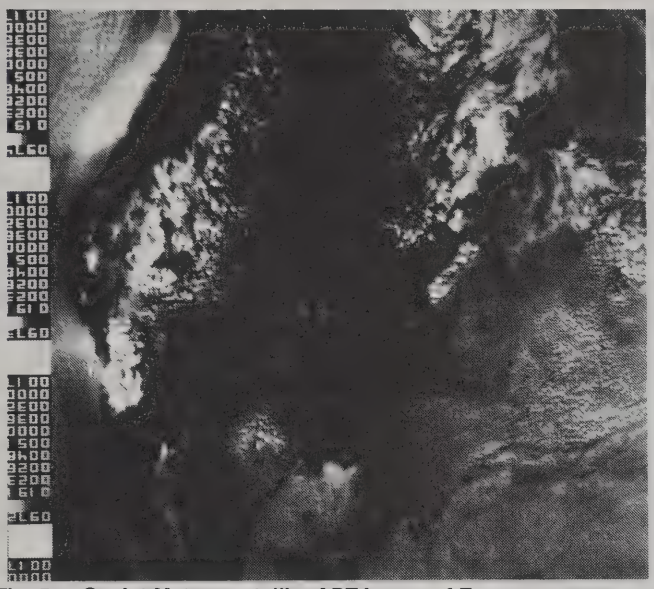

Fig. 5 — Soviet Meteor satellite APT image of Europe.

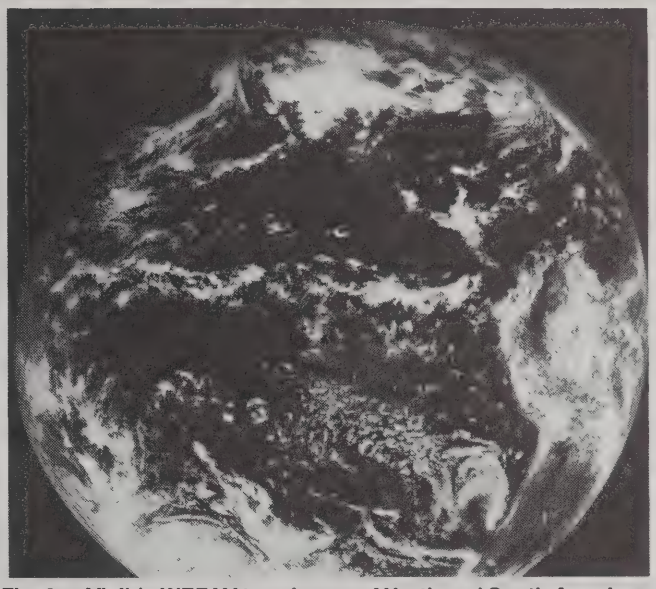

Fig. 6 — Visible WEFAX type image of North and South America.

and personal computer for image processing and storage. Figs. 3 & 4 show a typical APT visible and corresponding IR image of the European continent as imaged by NOAA 11 and captured at the ground station of I4GU. Fig. 5 is a Soviet Meteor satellite APT image of Europe. Note the difference in format.

Various AM demodulator cards with associated A-D circuitry and imaging software are commercially available for a variety of personal computers (Complete listings of vendors for APT receiving equipment and display systems may be obtained from the Dallas Remote Imaging Group BBS at 214 394 7438).

A critical component of the APT image display station is the resolution of the PC monitor and display card. There is a vast difference in picture detail, quality, and resolution obtained from APT data when comparing 2 bit (4 colors on screen), 4 bit (16 shades of grey scale) and 8 bit (256 shades of greyscale on screen) PC display systems. In the IBM PC domain, the older CGA display cards only display 4 colors (no shades of grey and worthless for APT imagery). The standard 16 shade VGA adapter cards give good APT images with a somewhat limited detail of lakes, rivers, and major cities. The newer Super VGA cards can display 256 shades of greyscale on screen, which gives truly outstanding APT images and very fine detail of small lakes, islands, and geographical features in the 4 km. per pixel limit resolution of the APT image.

Most APT software will display 640 pixels per line (4 km. per pixel), 480 lines on the screen, with 256 levels of greyscale for each pixel. With one megabyte of memory on a super VGA display card, 1024 pixels by 768 lines at 256 levels of grey give professional quality images on the home PC. (Most A-D converters are 8 bits, therefore the hardware is NOT the limiting factor).

A typical APT image, sampled at 9600 samples per second, for 16 minutes, will result in a digital file over 9 megabytes large. Adequate hard disk space (minimum of 40 meg. to be safe) is a must on any personal computer system used for satellite imagery.

Thus, with the simple addition of an AM demodulator card, A-D converter chip, software, and perhaps a super VGA display system for the PC, the current OSCAR satellite station may be easily upgraded to the fascinating world of APT weather satellite reception and image processing!

GOES WEFAX Imagery

In addition to the low Earth orbiting (LEO) weather satellites, the U.S., Japan, and European Space Agency also operate several satellites in geosynchronous orbits (35,800 km.) above the equator, providing continuous hemispheric meteorological coverage. The WEather FAcsimile (WEFAX)

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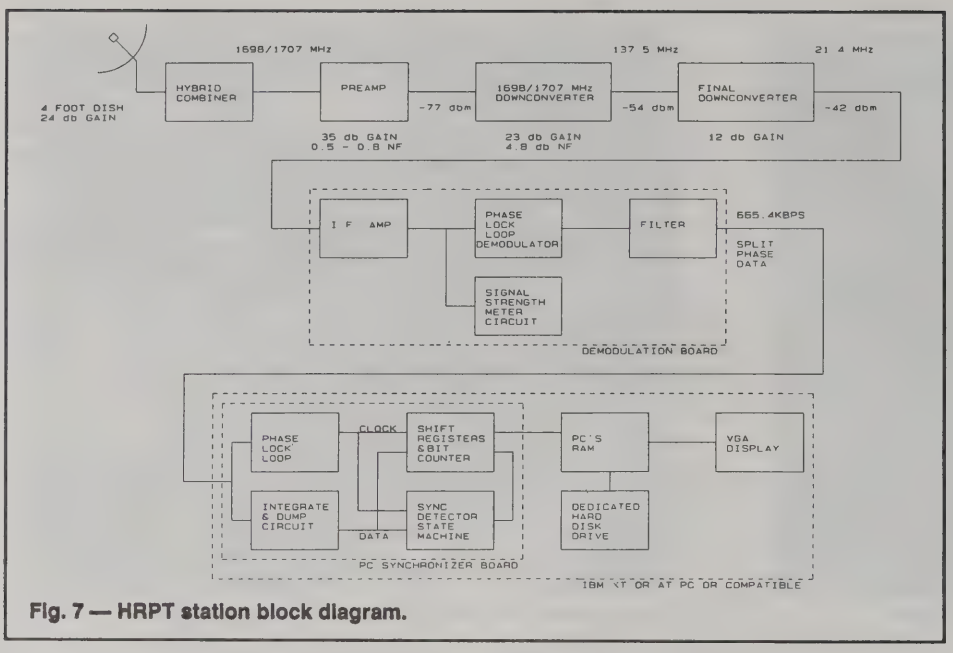

Fig. 7 — HRPT station block diagram.

images transmitted by the U.S. GOES satellites contain lower resolution analog images and charts transmitted at 240 lpm format similar to the analog APT data product. This aspect of WEFAX is important because image display systems that can reproduce the APT signals can be easily modified to display (8 km. per pixel) WEFAX images from GOES satellites. The WEFAX images are formatted in a 240 lpm transmission as compared to the 120 lpm rate for APT satellites. The WEFAX transmissions contain images of large quadrants of the Earth (visible and IR) that are transmitted on a pre-determined schedule 24 hours daily. These images are derivatives of a higher resolution product on the Visual Atmospheric Sounder (VAS) on the GOES platform.

In order to receive WEFAX images from GOES, additional components will need to be added to the APT system previously described. The WEFAX signal is transmitted at 1691 MHz. To capture this signal, a four foot parabolic dish (24 dB gain factor) is required to reflect the signal into a feed horn located at the focal point of the dish. A preamp and down converter are used to convert the 1691 MHz signal to 137.5 MHz, since there is a very significant attenuation and signal loss in coax cable at 1691 MHz. The 137.5 MHz output of the down converter is fed into the antenna jack of the 137 MHz APT receiver used in the APT station. The signal now carries the 2400 Hz subcarrier, and the audio output is now fed into the standard APT AM demodulator circuit board and reproduced in a manner similar to the APT signals. The difference is the controlling software scans at 240 lpm, with an image consisting of 800 lines during a 200 second transmission (800 lines / 200 seconds) = 240 lines per minute. Geopolitical boundary overlays and digital image preprocessing are provided by NOAA command data acquisition stations prior to uplinking the processed WEFAX image to end user ground stations through GOES satellites. A listing of 1691 down converter equipment, antennas, preamps, and software may be obtained from the Dallas Remote Imaging Group. Fig. 6 shows a visible WEFAX type image of North and South America during a daylight scan.

HRPT Imagery: The Next Evolution

The AVHRR instrument on the NOAA polar orbiters provides a higher resolution (1.1 km per pixel) High Resolution Picture Transmission (HRPT) product containing all five spectral channels. The HRPT signal containing the entire digital data set is a 665.4 Kilobits per second split phase encoded phase modulated signal. It is transmitted at 1707 MHz (NOAA 9 & 11), or 1698 MHz (NOAA 10), or 1695.5 MHz (Chinese Feng Yun 1-2).

For the AMSAT experimenter, reception of HRPT imaging of NOAA and Chinese platforms can now be achieved with almost the same ground station hardware described for APT & WEFAX imagery. Complete details for building the HRPT station may be found in the April 1990 *Journal of Environmental Satellite Amateur Users Group (JESAUG)*, available from the Dallas Remote Imaging Group. A summary of the building block approach developed by Dr. John Dubois and Ed Murashie will be described below. Fig. 7 shows a block diagram of an HRPT station.

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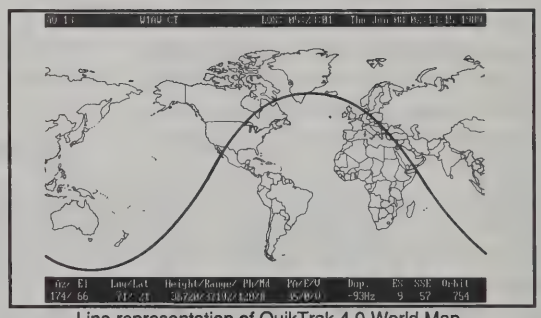

Line representation of QuikTrak 4.0 World Map

QuikTrak 4.0

Whether you want to identify the next time Oscar 13 will provide communications between two cities or if you just want to know the next time you can visually sight the Soviet space station MIR, QuikTrak will let you plug in the latest Keplerian elements for up to 100 satellites using a new full screen editor. QuikTrak also supports autotracking. *Hardware requirements*, IBM PC, AT, PS/2, or clone with a minimum 512K memory. CGA or EGA graphics required. Numeric coprocessor not required but recommended.

InstantTrack 1.0

For those concerned with greater speed and capability, InstantTrack offers all of QuikTrak's features plus instant visibility for your "favorite" satellites before you issue the first keystroke. More than 200 satellites and 1754 cities are on the menu and will be in full-color high-resolution EGA or VGA modes. *Hardware requirements:* IBM PC, AT, PS2 or clone with at least 512K memory. EGA or VGA graphics required. Numeric coprocessor not required but recommended. Mouse not required but can be used on the map screens.

These are only a few of the features of QuikTrak and InstantTrack. The figures below reflect suggested donations to defray production expenses and benefit AMSAT's non-profit, educational activities.

Recommended Donations:	Member	Non-Member
QuikTrak 4.0 5 -1/4"	$55	$75
InstantTrack 1.0 5 -1/4"	$50	$70

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The minimum antenna size using a state of the art LNA with a 0.5 dB noise figure and a 35 dB or more gain factor is a four foot parabolic dish with a gain of at least 24 dB. The dish must be mounted on an azimuth/elevation rotor mount similar to one used for tracking APT or OSCAR satellites (Yaesu 5400B rotors). The feedhorn is basically identical to the 'coffee can' feed widely described for WEFAX, but with two probes, 90 degrees apart for the circular polarized signal on HRPT. The signal output of the preamp is fed into a 1698/1707 to 137.5 MHz down converter (commercially available from Quorum Communications, Richardson, TX). The 137.5 MHz signal then needs to be down converted once again to a convenient frequency for PLL demodulation. Down conversion allows conventional phase demodulation techniques and components to be used, which is the next step in the process. The HRPT data is phase modulated onto the RF carrier with a swing of +/-67 degrees. A well designed PLL can lock onto a signal and deliver the split phase bit stream from the phase detector. The next step is to separate the clock and data bits by synchronizing a local clock to the clock rate of the transmitted data. Then the local clock is used to process the data and strip away the split-phase (Manchester) encoding used in the HRPT transmission. Following the bit sync and split phase decoding, the data must still be processed to identify the start of each line and to separate the different spectral bands of the HRPT signal. An essential part of this digital signal processing is to recognize the fixed bit pattern which identifies the start of each line. The 60 bit pattern is referred to as the frame synch and is the first 60 bits of the HRPT minor frame. The sync pattern also aids in determining which is the first bit of the 10 bit HRPT data words. By counting off the 10 bit words following sync, the desired image pixels can be saved in a format required by the computer display device. For the IBM PC, the desired image pixels can be saved to RAM memory or hard disk (At 665 kbps, a 16 minute pass including all 5 channels would require about 80 megabytes of storage!). Interface cards for standard IBM PC XT computers have been developed by the authors that demodulate, provide bit sync, decoding and synchronization. This IBM PC system brings all the data into the computer by DMA, and the software saves the desired channels on the hard drive during the pass. The selected images can then be displayed on the super VGA display. Fig. 8 is a visible HRPT image of the Baja peninsula. Fig. 9 is an HRPT image of S. California, the Salton Sea, and Lake Mead. Fig. 10 shows an HRPT visible image of San Francisco with fog visible in the Valley. The Sierras and Lake Tahoe are also included in the image. These outstanding HRPT images were captured by Ed Murashie on an IBM PC XT with manual antenna control, utilizing the system he developed with John Dubois. This is the type of unbelievable imaging capabilities available, today, at reasonable cost, to the AMSAT Amateur community!

Fig. 8 — Visible HRPT image of the Baja peninsula.

WEBERSAT Imaging: AMSAT'S Eye in the Sky

In June, 1990, a new opportunity for satellite image acquisition was presented to the Amateur community by the launch of the WEBERSAT polar orbiting satellite. WO-18 provides Radio Amateurs with a unique digital store and forward imaging capability. WEBERSAT carries a color CCD (charge coupled device), which is an all solid state imaging system. This Microsat also carries a high speed flash digitizer, L-band television receiver, a particle-impact detector, and Earth detector, a flux gate magnetometer, and a visual light spectrometer. This innovative and educational experimental package was designed and build by students and faculty of Weber State University and the Center for Aerospace Technology in Ogden, Utah. The color CCD camera output is either standard NTSC video with color burst, or separate red, green, and blue signals with horizontal and vertical synchronization. Chris Williams, WA3PSD, a critical mission planner for WEBERSAT, has indicated the camera resolution is 700 pixels by 400 lines. The actual imaging field of view is 19 degrees from an altitude of 810 km. Data from the CCD camera and other experiments are transmitted as beacon type packets using BPSK modulation at 1200 bps. The transmitter frequency is 437.100 MHz, with a backup of 437.075 (SSB).

The format of the picture for the CCD camera color composite signal is as follows as described by Chris Williams last February:

"Call sign (for this transmission scheme) is PHOTO (for the camera). SSID is picture number (modulo 16). We are currently often overwriting a given picture number with different pictures perhaps

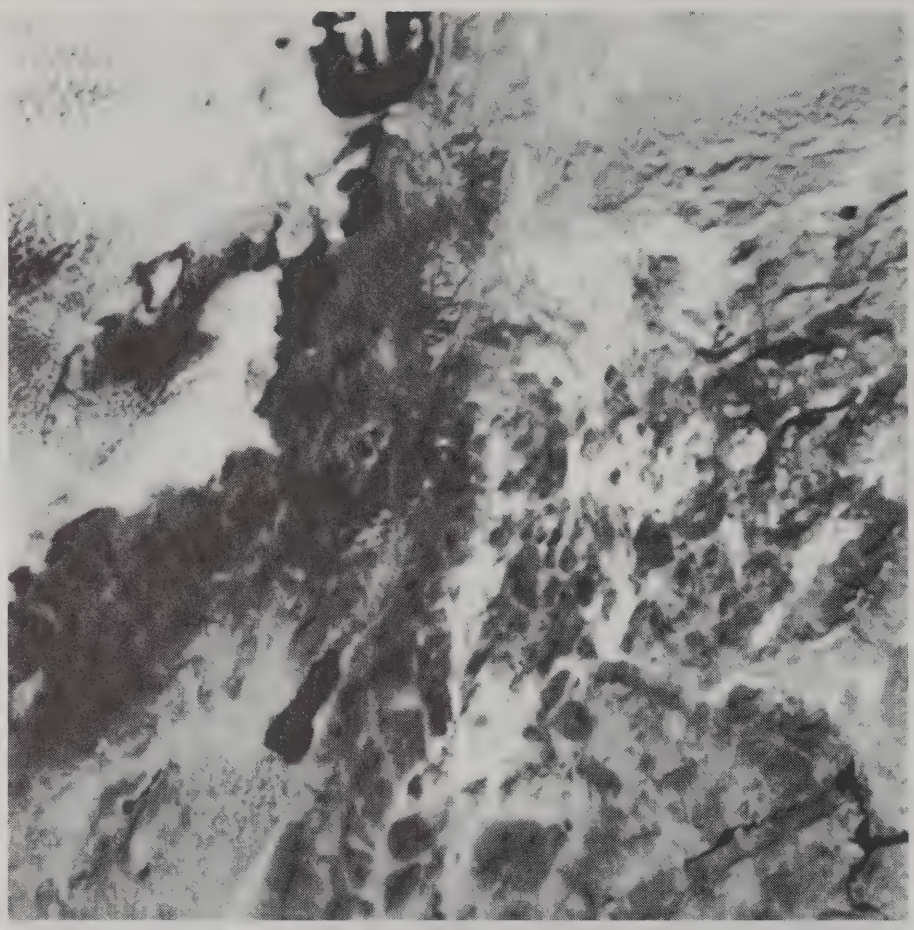

Fig. 9 — An HRPT image of Southern California, the Salton Sea, and Lake Mead.

twice a day. This is done when a picture is clearly black and there is no point in getting all of it.

The first two bytes of data portion of the UI frame (packet) contain the 10-bit X position of the first sample in that packet, the two most significant bits of the X position occupy the two least significant bits of the first byte, the eight least significant bits of X are in the next byte. Legal X values are from 0 to 644. Y values are in third byte and range from 0 to 241. If the two least significant bits of the first byte are both set (forming an X 768..1023), the data beginning with the second data byte is clear text information about the picture (which we call the "picture header") occupying 252 bytes. The six most significant bits of the first byte are reserved for future protocol definitions, only one of which is presently defined.

The data then consists of a sample for every third X value. This has little to do with RGB, but is relevant to color as the NTSC waveform is sampled at precisely 3 times the color burst frequency. A zero byte value indicates a simple compression sequence as follows: 00, the count of repeats, then the value repeated. Actual samples with a value of 0 (hor. sync) are changed to 1 to allow indicating a following compression sequence. When the X value is greater than 644, increment the Y value by two and subtract 645 from the X value. At the end of one of these compression passes, encoding returns to the top of the pic, moves one byte to the right and proceeds. This takes place three times to complete one half pic (every other line). Alternating half pics (even vs. odd) lines are transmitted every 101 minutes (every other visibility pass at these latitudes). There is not vertical sync transmitted. The picture begins at the end of the header.

The 645th byte of a reconstructed line is the count of zeroes which was in the original digitized sample between the 644th byte of that line and the beginning (the first non-zero) of the next line. If you are reconstructing the original waveform replace that

Fig. 10 — An HRPT visible image of San Francisco with fog visible in the Valley. The Sierras and Lake Tahoe are also included in the image.

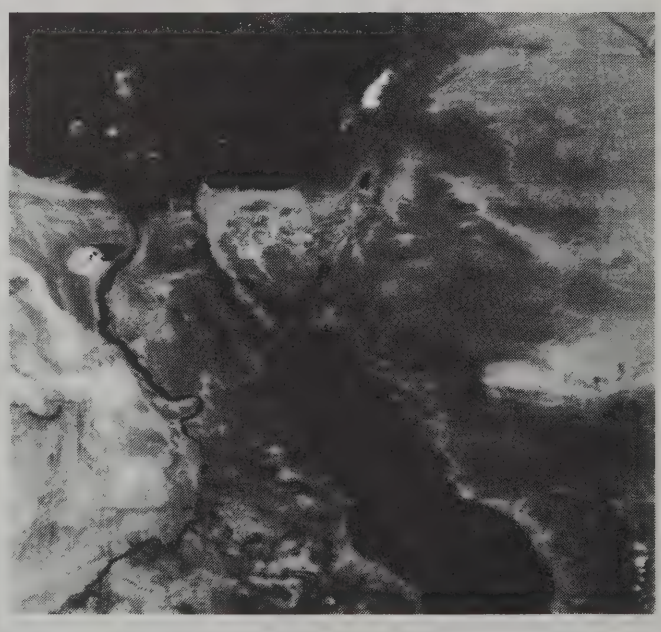

Fig. 11 — A high resolution image from the European Meteosat geosynchronous satellite (similar to GOES VAS) of a very "hot" area of the world.

count byte with that many zeroes.

I must again emphasize that this protocol is very temporary and can be expected to change with little advance notice. The compression scheme is poor and was selected only for its simplicity. It also will change. These changes will be handled with WEBERWARE version updates. Also, please note that we have the ability to download individual R, G or B signals from the camera and their protocol may be different. Ditto for the 1.2 GHz experiment. For those, however, you can expect a bit more advance notice of variation.

The high speed flash converter with 8 bit digital-to-analog conversion captures video from the CCD color camera and store the digitized image in random access memory on the satellite. Thus, multiple images may be compressed and stored for later downloading by PSK packet ground stations acquiring the WEBERSAT downlink signal.

A typical WEBERSAT ground station configuration would consist of a 70 cm. omni or directional beam antenna, preamp, PSK modem, packet TNC, 70 cm receiver, personal computer, and WEBERSAT display software package. It should be emphasized that adding imaging capabilities to the average OSCAR station can be implemented at minimal cost, and this fully complements the equipment required for APT and WEFAX reception. The WEBERSAT team has developed a preliminary image display software package (available through AMSAT-WEBERWARE 1.0) that allows display and image processing of the packetized digital image from space. The raw binary picture data from WEBERSAT is received through the PSK modem and TNC configured in KISS protocol mode, and stored on the PC hard disk as an ASCII file. KISS capture software is available on AMSAT BBS systems around the country. It requires two complete passes of WO-18 to display a full image on the PC. Actual picture file size is around 156 Kbyte after merging and processing within WEBERWARE 1.0.

Other Image Processing Software

There is a host of additional image processing software for the personal computer that will fully enhance the display of APT, HRPT, WEFAX, and WEBERSAT imagery. These applications can show histograms of the pixel distributions, conduct low and high pass filtering, eliminate random noise in images, bring out detail not observable in the raw data, do contrast stretch, sliding, and edge detection. Programs such as IMDISP, a public domain application from the Jet Propulsion Laboratory, utilize the same routines used on the Viking, Ranger, and Voyager space missions for digital image processing. Programs costing thousands of dollars just several years ago may now be obtained free of charge through the Shareware concept.

Various GIF viewers (Graphical Interchange Format) are available to view raw 8 bit image files across a variety of PC operating systems, in 256 shades of gray and colors. Many image files can be imported in paint programs for further color enhancement and false coloring to bring out rotation in hurricanes, show the thermal currents in the oceans, give a 3-D effect to cloud heights, etc. Many GIF viewers such as PICEM and VPIC allow for animation of weather satellite imagery in a story board manner.

Several days worth of weather systems may be constructed into a time sequenced motion showing travel of frontal systems, etc. The possibilities are almost endless. These programs may be found on the DRIG BBS and other computer BBS systems around the U.S.

In summary, the Amateur satellite sleuth now has a vast array of image acquisition and display systems available to fully complement his OSCAR satellite ground station. This capability can all be added at a very small incremental cost, but provides an exponential growth in professional capabilities. And to leave you with a further enticement, Fig. 11 is a high resolution image from the European Meteosat geosynchronous satellite (similar to GOES VAS) of a very "hot" area of the world. Can you guess where it is?

Here's looking forward to your own personal "View from Space"!

The author encourages all AMSAT members to check into the BBS to gain further information on the exciting world of satellite image processing.

The author may be contacted at the following address:

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PO BOX 117088
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214 394 7438 (BBS)
214 394 7325 (voice) ■

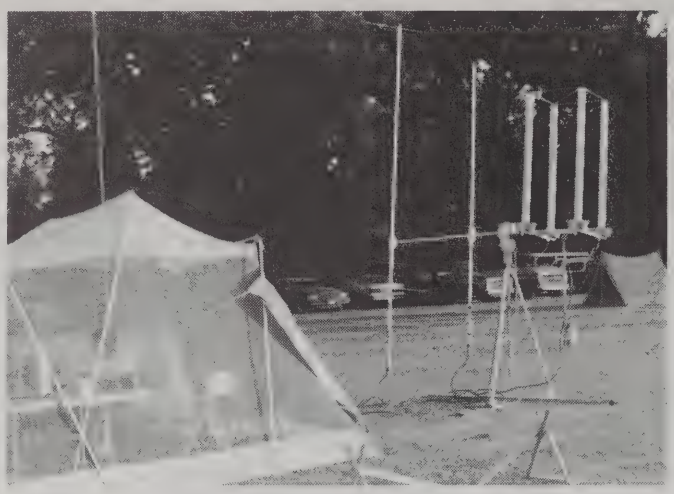
Keeping Amateur Radio In Space

(Continued from page 3)

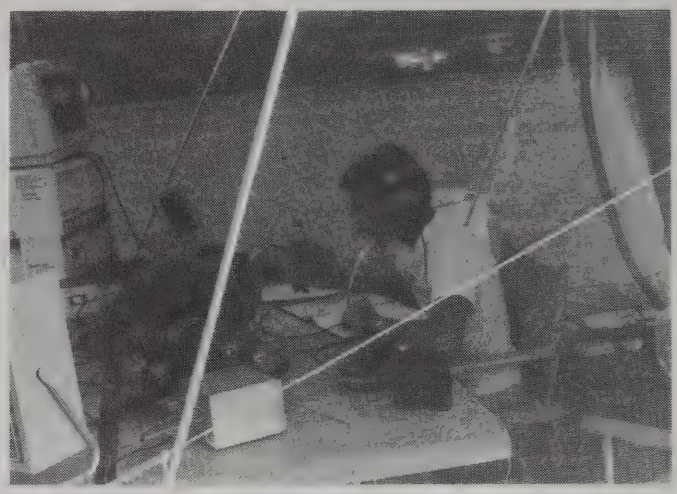
tant piece of justification that the legislators look at when reviewing the Amateur's right to frequency spectrum. As we face another WARC in the very near future it is time for us, the Amateur satellite operators, to demonstrate that we can use our small allocation of spectrum to support public service.

There is no better way for us to do this

This is the Field Day station of Mike Crisler, N4IFD, *located on his boat.* He used it successfully during Field Day last year as well as on a Dx-pedition to the Bahamas (C6A). He has even made Mode L contacts while underway! (For Field Day he also has a 30' tower and Tribander on the stern). His secret weapon this year is a customized version of the WØSL ORBITS tracking program that allows the direct input of his boat's heading.



W5IU, General Dynamics/ Ft. Worth Radio Club Field Day Satellite Station.

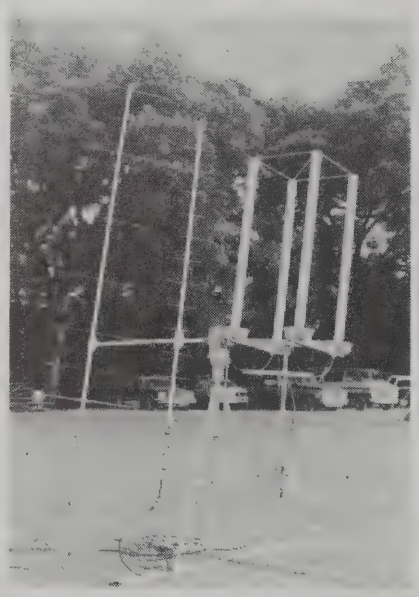


Doug, KG5OA at the mike of W5IU.

than to make a strong showing during Field Day on June 22-23. With almost a dozen operating satellites, this is the year for AMSAT members to show that we too can significantly contribute to communications from locations other than the comfort of our shacks. In support of this goal AMSAT is proud to announce its first ever "Field Day Excellence" award. At this year's Space Symposium (Nov 8-10 in Southern California) I will be presenting a substantial award to the team from AMSAT that scores the most points during Field Day using Amateur satellites. To enter all you need to do is send a copy of the official ARRL Field Day entry form to AMSAT headquarters with a separate tally of the points earned using just satellites. (This can be a copy of the entry you send to ARRL with just the points made on the satellites tallied separately from those on HF, etc.) Points will be awarded in accordance with the established rules as published by *QST*. I would also like a photo of your Field Day satellite station to publish in a special *Journal* article that will recognize all those who enter this contest. As we get closer to the date more information will be available on the AMSAT News Service and the AMSAT Nets.

But don't just enter for the sake of the prize or the recognition. Enter because you support our goal of keeping Amateur Radio in Space. We need all of the support we can muster in the upcoming WARC to prevent loss of some of the spectrum that the Amateur Satellite service will need to continue to grow. By your support in starting now to assemble a portable satellite station and using it on Field Day you will be doing something for our service that no one else can do-showing the rest of the Amateur community and the world that AMSAT can be depended upon to perform public service when the need arises.

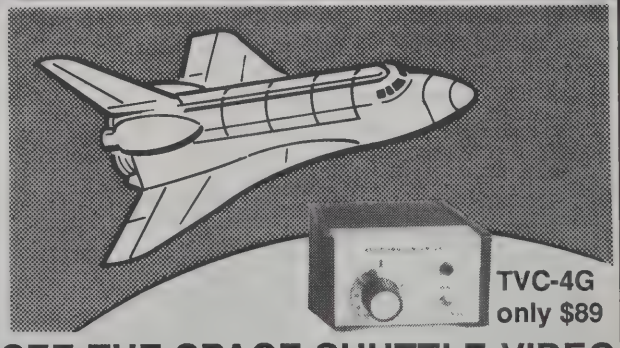
I'll be on the birds on June 22-23; I hope to work you from my Field Day station. If we take this seriously we all will be helping to Keep Amateur Radio in Space! — *Doug Loughmiller, KO5I* ■



The Satellite Antenna Farm at W5IU.

Need a software package for working OSCAR 13 on Field Day? See page 22 for details

AMATEUR TELEVISION



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AMSAT Orbital Data Management

Reprinted from the Proceedings *of the AMSAT Symposium.*

By Dick Campbell, N3FKV
AMSAT Operational Coordinator for Orbital Data Management

Nothing is nearer and dearer to the heart of a satellite chaser than a current set of accurate Keplerian orbital elements. AMSAT responded to this need as personal computers began to proliferate in Ham shacks, pushing aside the *OSCARLocator* as the primary satellite tracking means. The first programs were limited in capability, and data entry was accomplished manually by most users. Vern Riportella, WA2LQQ, then President, began the original distribution of the AMSAT element set format via the weekly Nets and the AMSAT *Amateur Satellite Report (ASR)*. The format with which everyone is now familiar grew out of a desire to make the two line element sets distributed by NASA an easily readable tool for the manual user.

The Keplerian numbers do not appear out of thin air, of course. NORAD has the mission to keep track of all objects in orbit, and it is their radar tracking that generates the weekly data. This is passed to NASA for further distribution to the public. Anyone can obtain a printed weekly listing simply by asking, but this is a service provided by AMSAT to all. With the advent of packet radio and the growth of that distribution network, it was logical to proceed to an electronic format. Two new volunteers emerged on the scene, Courtney Duncan, N5BF, and Ralph Wallio, WØRPK. Courtney would write the software to create the bulletins and Ralph would see that they were put together every week for distribution. For the past several years, you would have been quite familiar with Ralph's call sign if you were catching the weekly AMSAT orbital bulletins. The hard part of all this — element sets still had to be transcribed manually from the NASA mailings. Certainly it was a tedious undertaking, and inefficient in this day of ""workaholic"" PCs, but necessary nonetheless.

Call For ODM

In late 1989, Ralph was unable to continue the weekly chore as Orbital Data Manager, and the duty fell to Courtney, who had assumed duties as the Vice President of Operations in the meantime. When he called for help, I raised my hand (I obviously had been listening to too much telemetry) and took over the weekly duties of distributing AMSAT element sets to the world. The good news was that now all element sets were available electronically from T.S. Kelso and his Celestial BBS. He is participating in a pilot program with NASA for their eventual electronic mailing system. The bad news was that all sets from Celestial were in the 2-line format and no software or standard existed to guide me in the conversion. Those first few releases generated several howls from software users whose files would crash because of extra white space, carriage returns, and extraneous text. However, once those bugs were identified, I was able to put together a software package that makes the whole process automatic and relatively painless, and is compatible with existing tracking programs.

This automated distribution software is written in C and compiled BASIC, and is running on an OS-9 system. Once the elements are downloaded from Celestial BBS, the AMSAT birds are sorted out and the checksum of the NASA 2-line is verified. Then the sets are translated into the AMSAT human readable text and packaged into the packet bulletin format we all know and love. I then place this file on AMSAT's electronic mail service where it is picked off by a host of dedicated volunteers, packet sysops, Net Controls and the *OSCAR Satellite Report* (*ASR's* unofficial successor). This gets the weekly bulletins into the networks and on the air for your use. The whole process takes about 30 minutes, hands off.

My final act is to archive that week's file in the event elements are needed for research, such as the recent AO-13 orbit studies. I am retaining all element sets I

Satellite Orbital Elements May 9, 1991

```
AO-10
1 14129U 83058  B 91121.60065856 -.00000148           99998-4 0  6719
2 14129  25.8131 148.0591 6035385 238.5955  48.7305  2.05930413 31282
RS-10/11
1 18129U 87054  A 91122.55873330 0.00000097           99999-4 0  6355
2 18129  82.9239  92.5743 0010665 318.9430  41.0927 13.72181431193335
UO-11
1 14781U 84021  B 91112.15521359 0.00005210           94110-3 0  9996
2 14781  97.9072 159.0451 0013377 351.4612   8.6363 14.66793488381234
RS-12/13
1 21089U 91007  A 91121.52227182 0.00000210           21213-3 0   737
2 21089  82.9237 138.7019 0030979  50.5396 309.8488 13.73893673 11730
AO-13
1 19216U 88051  B 91121.30113593 0.00000118           99999-4 0  2711
2 19216  56.8390  97.0967 7167973 253.2812  22.8340  2.09698033 22073
UO-14
1 20437U 90005  B 91122.22417975 0.00001104           45135-3 0  3789
2 20437  98.6640 201.9252 0010286 302.6115  57.3972 14.29099943 66428
AO-16
1 20439U 90005  D 91122.47208996 0.00001024           41897-3 0  2779
2 20439  98.6731 202.4976 0010865 309.3328  50.6876 14.29185843 66461
DO-17
1 20440U 90005  E 91121.96499687 0.00001157           47064-3 0  2783
2 20440  98.6740 202.0372 0011782 310.4248  49.5835 14.29267592 66398
WO-18
1 20441U 90005  F 91122.14653391 0.00000930           38140-3 0  2771
2 20441  98.6706 202.2637 0011394 308.1072  51.9081 14.29315082 66427
LO-19
1 20442U 90005  G 91121.98343586 0.00000926           37882-3 0  2783
2 20442  98.6714 202.1563 0011916 309.2827  50.7277 14.29390739 66408
FO-20
1 20480U 90013  C 91122.45970617 0.00000113           30151-3 0  2238
2 20480  99.0236 113.3081 0541716  45.2167 319.1703 12.83194721 57690
AO-21
1 21087U 91006  A 91122.45492809 0.00000283           28809-3 0   724
2 21087  82.9387 267.5573 0036064  28.2952 332.0147 13.74379605 12748
MIR
1 16609U 86017  A 91122.53643102 0.00041942           40528-3 0  4472
2 16609  51.6051 158.9464 0008449 166.6956 193.4219 15.65973348298013
FENGYUN
1 20788U 90081  A 91122.37577184 0.00000008           16949-4 0  1846
2 20788  98.9458 156.8504 0014546 304.0638  55.9151 14.01133746 33791
```

have generated in my tenure, and will pass them along whenever needed. I also try to keep my eyes open for new launches and include them in the bulletin when they are of interest to the Amateur community, such as the launch of the Pakistani satellite, BADR-1. I am always open to suggestions if we are not carrying something the users would like to see on a regular basis. I do not, however, have control over editing processes that take place down the line, so if your source does not carry a particular set, you need to advise them directly.

Still Some Problems

The current system is not without its problems. There is no documented standard for our format, thus someone else could not easily take over the duties. NASA does not always have correct values for some of our birds, and in fact reports erroneous data on occasion. Witness the FO-20 confusion last spring. NASA/NORAD still has the orbit number of AO-10 wrong in their sets (but the AMSAT release shows the correct value). The weekly release of every element set puts a burden on the packet network when it is not really necessary to update every set every week. But we do like to have the most recent set, don't we? Probably the most glaring omission is the lack of error checking on the user end. While I checksum what I receive from Celestial to ensure I'm starting with a good dump, the user has no way of knowing if the numbers obtained via packet or voice net were transmitted correctly. Finally, I presently do not have the manpower or the means to check the reasonableness or consistency of element sets from week to week. This would be a nice service to provide, and would identify problems early, such as the FO-20 confusion.

The Standard

The need for a published format Standard is obvious, and has been the main thrust of my efforts this year. Not only would a Standard facilitate software developers of new tracking software, it would guarantee compatibility to existing software. It would also allow the easy transfer of duties in our volunteer organization without causing major ripples in the bulletin content. This Standard should provide for future expansion while retaining backward compatibility. It would be nice to eventually add error checking, transponder schedules, and perhaps even Bahn coordinates to the sets. The proposed "AMSAT KEPLERIAN ELEMENT SET STANDARD" is being reviewed by software developers, users and AMSAT Officers for ultimate approval and implementation. Once approved by AMSAT, it will be published, and copies will be available to users and software authors. I mention this here to solicit comments and suggestions from you, the ultimate target, before being etched in stone.

The AMSAT User Community

Early in 1990, I conducted a survey on the voice Nets and via a packet bulletin. The response was international in scope and represented a good cross section of our membership. In this age of high speed turbo megabuck PCs, why (you ask) do we still bother with the inefficient, redundant verbose format that eats up bulletin space and is not conducive to machine manipulation? I'm glad you asked. Surprisingly, the majority of respondents still enter their data manually, therefore the format must be human readable. Also, there is something to be said for "looking" at the Keplerian elements and understanding what the bird is doing. Besides, you should be doing your own reasonableness checks. How else will you know something is amiss? The type of computer used was split between 50% IBM (or clone) and all others. But "all others" is still 50% of the user group, so we have to retain compatibility with a number of machines. The key is not to get machine dependent. The other surprising result was that the most popular source of data was packet and the voice nets, about an even split. Also, many are still using printed media. It is important to serve the entire community, and hence the wide variety of distribution means. The most remarkable comment I received concerned garbled packet data. You would think this would not be possible but apparently it happens. This, more than anything else, dictates the critical need for an error checking "checksum" function at the user end, and has been included in the proposed Standard. Hopefully these and future surveys will steer us to always providing the best service possible. So, the onus is on you, the end user, to respond!

So What's Reasonable?

When you look at your new element set, how can you check that the elements appear correct? And what do they tell about the orbit of this bird? You can gain a better understanding of orbits in general and your operating success in particular if you know something about the parameters and their effect on the orbit. So, a short tutorial is in order.

The first thing you should do is compare the new set to a previous set. The best way to do this is to run the bird on both sets for the same time and make sure the results are nearly equal. Then take a look at each of the parameters. On all types of orbits, the inclination and mean motion will not change appreciably. The highly elliptical orbits of AO-10 and AO-13 will change very slowly, so all parameters should show only a slight change. The argument of perigee precesses only a fraction of a degree per day on these orbits. You should also be aware that NASA (actually NORAD) normalizes all parameters to the ascending node (equator crossing) for the epoch time in the set. That is, the elements reflect the position of the bird at the ascending node at that time. Let's look at each parameter:

a. Catalog Number: this is the reference number assigned by NASA and will not change. Some tracking programs use this to update element sets when reading a Keplerian file.

b. Epoch Time: this number should show the current year and the three digit Julian day (which should be greater than the day in a previous set). The fraction is the time of day in decimal days, and can be converted to hours, minutes and seconds.

c. Element Set: increases sequentially to identify the most current set. This is also modulo 999, so after set number 999, the next set will be number 1.

d. Inclination: by definition, is between zero and 180 degrees measured at the ascending node from the equator. If this number is zero, the orbit is equatorial (and is probably a geo-stationary satellite). A low value indicates the bird stays in the low latitudes. If you live far north or south, your visibility windows would be limited. Most Space Shuttle missions will use a 28 degree orbit and stations above about 45 degrees latitude will never see the shuttle above their horizon. Stations above 28 degrees will never have an overhead pass. Conversely, an inclination near 90 degrees is a polar orbit which will cover the entire Earth several times in 24 hours. If it is slightly greater than 90 degrees, the Microsats for example, the orbit will be near sun-synchronous, meaning the bird will appear at approximately the same times every day.

e. Right Ascension of Ascending Node: this is the equator crossing point measured easterly from the first point of Aries and can have a value from zero to 360 degrees. It is this parameter that ties the satellite position to the clock and the Earth's rotation. The epoch time given in the set is the time of the ascending equator crossing (node) at this angular position.

f. Eccentricity: describes the ellipticity of the orbit. A value of zero is a perfectly circular orbit, but it must always be less than 1.0 for the spacecraft we are tracking.

g. Argument of Perigee: The angle measured from the ascending node (equator crossing) forward in the orbit to the

perigee. This will have a value between zero and 360 degrees and will be the location of perigee at the epoch time.

h. Mean Anomaly: This angle is measured forward in the orbit from perigee to the satellite position, zero to 360 degrees. In a circular orbit, it is the number of degrees from perigee around the circle. Remember we said that the RA of node was the position of the satellite at the epoch time. In other words, the satellite is at the equator at this time. Therefore, the mean anomaly in this set will also be the angle from perigee to the equator. This means that, for circular orbits only, the sum of argument of perigee and mean anomaly will always be equal to 360 degrees (plus or minus a small fraction due to the slight eccentricity). This is another check you can make, but it is only valid for those normalized sets promulgated by NASA.

i. Mean Motion: the number of revolutions (orbits) the bird makes in one solar day. Dividing this number into 1440 minutes / day will give you the orbital period in minutes. It should not vary to two or three decimal places, unless the spacecraft is conducting orbital maneuvers, such as the Space Shuttle or Mir, or if it is near re-entry.

j. Decay Rate: the first derivative with respect to time of the mean motion. Its magnitude varies inversely with the satellite altitude. This parameter will have a very small effect on your output, but can skew results if you are using a set that is several months old. Simply make this value zero in your tracking program if you have an old set, and your solution will be close enough for normal Amateur operations. This value represents all of the unmodeled but observed perturbation factors in an orbit. For a new launch, it is useful only after several weeks of data are taken.

k. Epoch Rev: the revolution or orbit number for the given epoch time. It is a nice number to put on your QSL card and tells you something about the age of the satellite, but it does not enter into tracking computations. The orbit number theoretically increments at perigee, but NASA increments at ascending equator crossings. Significant differences will be seen only in the low orbit birds, whose perigee precession laps the equator more often.

The Future

What is in the future for AMSAT orbital data? With the Microsats and FO-20 flying high and providing good signals, it would be relatively easy to include each bird's own current elements in its beacon. Software could automatically read that transmission and update your tracking software. Establishing a corps of volunteers to track and check the elements we release would validate our data and could even lead to a capability to compute our own element sets, a technical challenge that may be appealing to some. On the bulletin side, I will investigate modifying the release schedule so that current sets are available only as often as necessary for the type of orbit, thereby relieving congestion on the distribution network. There will be many fun things to do, but all requiring volunteers who like to write software, reduce telemetry, operate packet and landline BBSs, or verify orbits. I will be receptive to all takers, and if you have a favorite bird you would like to start watching, let me know and I will get you involved. My first real requirement is for an assistant or two, someone who can also pick up the weekly duties on occasion (so I can go on vacation and you still get your data!).

All in all, I have really enjoyed this job and hope you will get involved too. We are part of a great organization and it needs your active support. We have a challenging future ahead of us as we upgrade our capabilities. Catch me "on the birds", I look forward to meeting you and discussing these issues. ■

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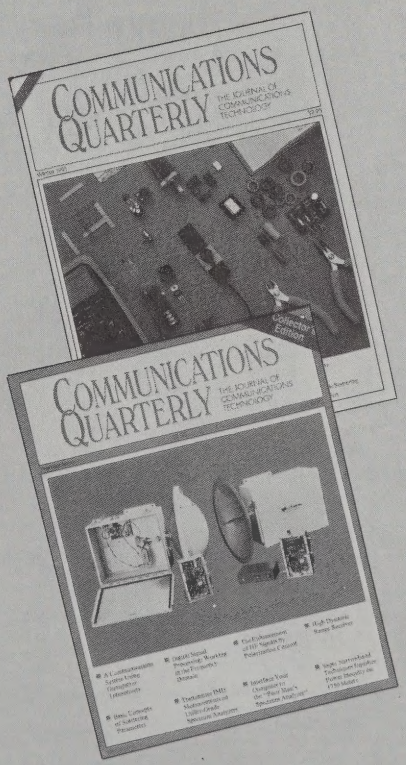

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Microsat Software and the AEA PK-232

(Continued from page 11)

up PG.EXE. You can now switch the TAPR PSK on again.

To change from PG to PB simply reverse the above procedure.

It is to be hoped that in the future software developers will take into account that there are probably more PK-232 TNCs out there than TNC-2s and that they should at least provide versions of their software that understand the PK-232 handshaking protocols. Most of the current terrestrial packet software has this facility (Packet-Gold, Lan-Link etc.)

If you follow these procedures you should be able to get your system up and running with the minimum of trouble. Good luck and happy satelliting. ■

Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	$29.95
P50VD	50-54	<1.3	15	0	DGFET	$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

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Satellite Orbital Elements

(From page 18)

Line 1 is the satellite's name.

Lines 2 and 3 are the standard Two-Line Orbital Element Set Format identical to that used by NASA and NORAD. The format description for Line 2 is:

Column	Description
01-01	Line Number of Element Data
03-07	Satellite Catalog Number
10-11	*International Designator (Last two digits of launch year)
12-14	*International Designator (Launch number of the year)
15-17	*International Designator (Piece of launch)
19-20	Last two digits of epoch year
21-32	Epoch (Julian Day and fractional portion of the day)
34-43	Drag or Decay Rate
45-52	*Second Time Derivative of Mean Motion (Blank if N/A)
54-61	*BSTAR drag term if GP4 general perturbation theory was used. Otherwise, radiation pressure coefficient.
63-63	*Ephemeris type
65-68	Element set number
69-69	*Check Sum (Modulo 10) (Letters, blanks, periods = 0; minus sign = 1; plus sign = 2)

(*generally not necessary or applicable to most AMSAT software. InstantTrack uses the check sum to determine if the element set is correctly formatted.)

The pertinent items in Line 2 translate as:

Catalog ID:	19216
Epoch Year:	90
Epoch Day:	21.40340404
Drag:	-0.00000075 revs/day/day
Element set:	70

The format description for Line 3 is:

Column	Description
01-01	Line Number of Element Data
03-07	Satellite Catalog Number
09-16	Inclination in degrees
18-25	Right Ascension of the Ascending Node in degrees
27-33	Eccentricity (a leading decimal point is assumed)
35-42	Argument of Perigee in degrees
44-51	Mean Anomaly in degrees
53-63	Mean Motion in revolutions (orbits) per day
64-68	Orbit number at the epoch given above
69-69	Check Sum (Modulo 10)

The pertinent items in Line 3 translate as:

Catalog ID:	19216
Inclination:	57.1171 degrees
RA of Node:	172.3126 degrees
Eccentricity:	0.6876271
Argument Perigee:	219.5193 degrees
Mean Anomaly:	61.5621 degrees
Mean Motion:	2.09701111 revs/day
Orbit #:	1232

This is what the entire AMSAT-OSCAR 13 two-line element set translates to:

Satellite:	AO-13
Catalog ID:	19216
Element set:	70
Epoch Year:	90
Epoch Day:	21.40340404
Drag:	-0.00000075 revs/day^2
Inclination:	57.1171 degrees
RA of Node:	172.3126 degrees
Eccentricity:	0.6876271
Argument Perigee:	219.5193 degrees
Mean Anomaly:	61.5621 degrees
Mean Motion:	2.09701111 revs/day
Orbit #:	1232

■

The Satellite Experimenter's Handbook

If you're:

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- **A teacher**
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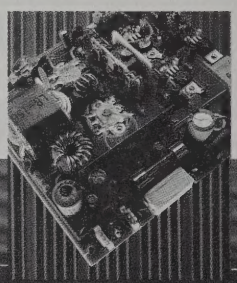
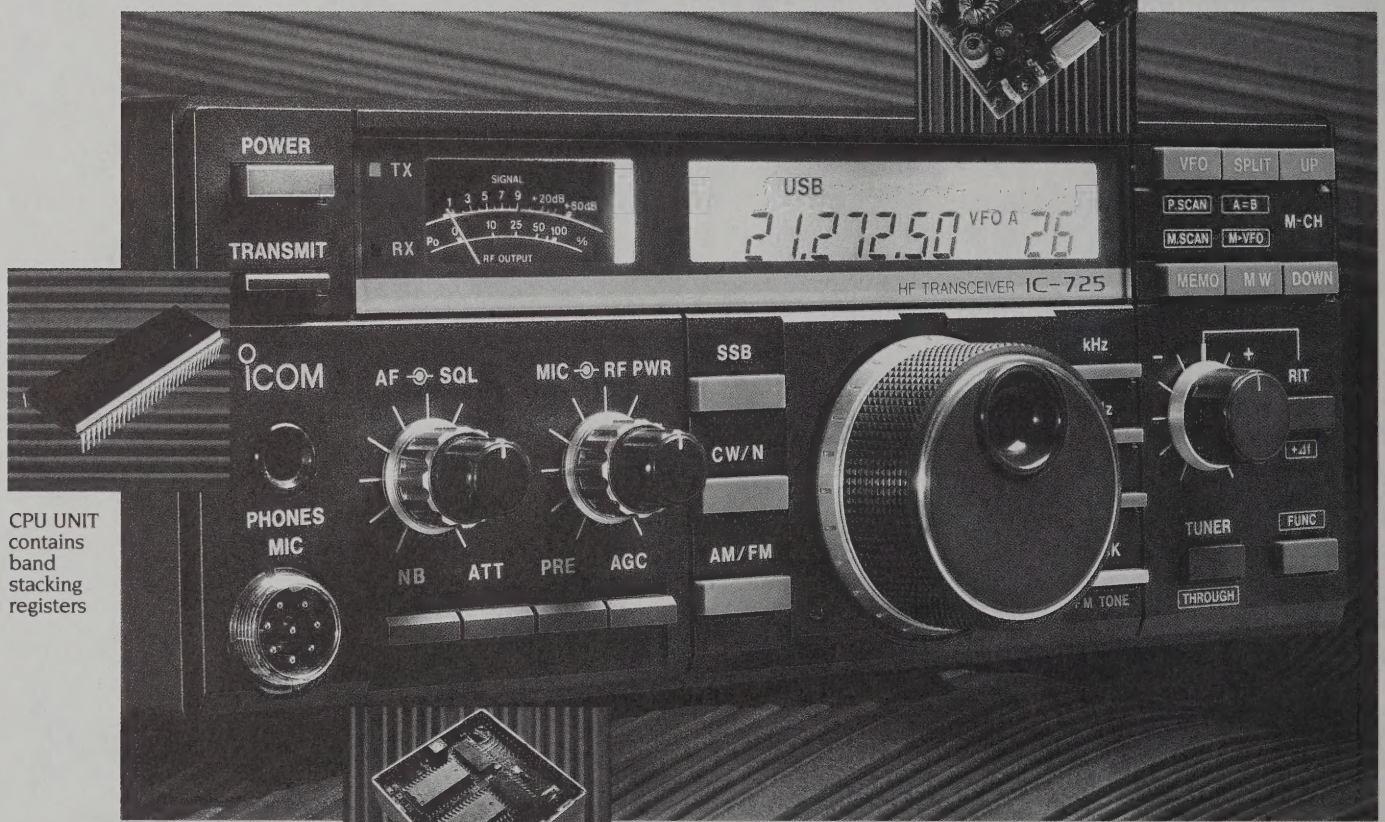
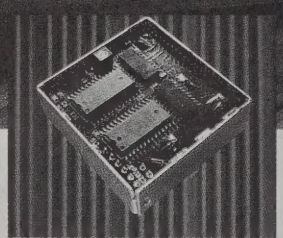


PA UNIT
provides 100%
duty cycle



CPU UNIT
contains
band
stacking
registers



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